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PRODUCT ASSURANCE,

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RADIO SYSTEMS TECHNICAL EVALUATION.

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31 MARCH 1977

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U. S. ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA, ARIZONA 85613

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This document provides a guide for testing, evaluating, and characterizing the transmission quality and functional capability of the post, camp, and station, single channel frequency modulated radio networks and high frequency amplitude modulated and single sideband systems.

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USACC Pamphlet
No. 702-8

31 March 1977

Product Assurance

RADIO SYSTEMS TECHNICAL EVALUATION

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CHAPTER 1

INTRODUCTION

1-1. PURPOSE. This document provides a guide for testing, evaluating, and characterizing the transmission quality and functional capability of the post, camp, and station, single channel frequency modulated (FM) radio networks and high frequency (HF) amplitude modulated (AM) and single sideband (SSB) systems. Multichannel FM radio systems are to be evaluated in accordance with appendix G, CCP 702-1.

1-2. OBJECTIVES. The objectives of the radio systems technical evaluations are:

a. The acquisition, analysis, and evaluation of:

(1) System transmission and radio equipment to determine performance parameters.

(2) Noise interference data as encountered in the operational systems.

(3) Maintenance, operational, and logistical data to provide information for more efficient operation.

b. The development, application, and enforcement of improved operational, logistical, and maintenance standards, methods, procedures, and criteria.

c. To provide this headquarters and subordinate commands with transmission data and operational performance characteristics of the non-DCS systems in support of future planning.

d. To provide maximum assistance and over-the-shoulder training to onsite personnel during scheduled testing.

1-3. CONCEPT. Evaluating, characterizing, and documenting the performance capabilities of the HF systems and FM radio networks are essential elements in assuring quality service to our subscribers. This program, when implemented and completed will improve operations and fill a void in the quality assurance program of the non-DCS.

1-4. REFERENCES.

a. CCR 702-1-3, USACC Quality Assurance Program for Operational Communications-Electronics Systems and Facilities.

b. TM 11-5815-334-12, Operator and Organizational Maintenance Manual Including Repair Parts and Special Tool Lists: Radio Teletypewriter Sets AN/GRC-142, AN/GRC-142A, AN/GRC-142B, AN/GRC-122, AN/GRC-122A, and AN/GRC-122B, 22 May 70.

c. TM 11-5820-401-12, Operator's and Organizational Maintenance Manual Including Repair Parts and Special Tools List: Radio Sets AN/VRC-12 (5820-223-7412), AN/VRC-43 (5820-223-7415), AN/VRC-44 (5820-223-7417), AN/VRC-45 (5820-223-7418), AN/VRC-46 (5820-223-7433), AN/VRC-47 (5820-223-7434), AN/VRC-48 (5820-223-7435), AN/VRC-49 (5820-223-7437), AN/VRC-54 (5820-223-7567), and AN/VRC-55 (5820-402-2265); Mounting MT-1029/VRC (5820-893-1323) and Mounting MT-1898/VRC (5820-893-1324); Antenna AT-912/VRC (5820-897-6357); Control, Frequency Selector C-2742/VRC (5820-892-3343) and Control, Radio Set C-2299/VRC (5820-892-3340) (NAVELEX 9067-432-3011), 7 Sep 72.

d. TM 11-5820-475-12, Operator and Organizational Maintenance Manual: Transmitting Set Radio AN/FRT-52A, 16 Jan 62.

e. TM 11-5820-480-35, Field and Depot Maintenance Manual: Modulator Power Supply Group AN/URA-28A, 15 Feb 62.

f. TM 11-5820-504-20, Organizational Installation Manual: Radio Transmitting Sets AN/FRT-52A and AN/FRT-54A, 21 Dec 62.

g. TM 11-5820-520-12, Operator and Organizational Maintenance Manual: Radio Sets AN/GRC-106 and AN/GRC-106A, 25 Feb 71.

h. TM 11-5820-529-15, Organizational DS, GS, and Depot Maintenance Manual: Transceiver RT-718/FRC-93 (Collins Model KWM-2 and KWM-2A), Power Supply PP-3990/FRC-93 (Collins Model PM-2) Power Supply PP-4151/FRC-93 (Collins Model 516F-2) Crystal Unit Set Quartz CK-31/FRC (Collins Crystal Packet CP-1) Including Repair Parts and Special Tool Lists, and Installation and Operating Instructions for Waters Q-Multiplier/Notch Filter, Model 340-A, 25 Jun 64.

i. TM 11-5820-532-15, Organizational, DS, GS, and Depot Maintenance Manual Including Repair Parts and Special Tools List: Amplifier, RF AM-3979/FRC-93 (Collins Model 30L-1), 28 Jan 65.

j. TM 11-5820-554-15, Organizational, Direct Support, General Support, and Depot Maintenance Manual Including Repair Parts and Special Tools List: Radio Set AN/FRC-93, 15 Jul 65.

k. TM 11-5820-805-14, Operators, Organizational DS and GS Maintenance Manual: Receiver, Radio AN/GRR-23, FSN 5820-123-3937 and Receiver, Radio AN/GRR-24, FSN 5820-123-3945, 25 Jun 73.

l. TM 11-6625-454-35, Field and Depot Maintenance Manual: Spectrum Analyzer Group AN/URM-116A, 15 Feb 62.

1-5. RECOMMENDED TEST EQUIPMENT. A listing of preferred test, maintenance, and diagnostic equipment (TMDE) necessary to perform the tests is shown in appendix A. Other equipment may be used if the electrical characteristics are equivalent to those of the recommended item.

1-6. COMMENTS. Users of this pamphlet are invited to submit recommendations to improve the pamphlet. Comments should be keyed to the specific page, paragraph, and line of the text. Rationale should be provided for each comment to insure understanding and complete evaluation. Comments should be submitted on DA Form 2028 (Recommended Changes to Publications) and addressed to Commander, US Army Communications Command, ATTN: CC-OPS-O, Fort Huachuca, AZ 85613. (Copies of DA Form 2028 are bound in the back of this pamphlet.)

CHAPTER 2

TECHNICAL EVALUATION GUIDELINES

2-1. DISCUSSION.

a. Before conducting a technical evaluation, a test notification message will be sent to the command to be evaluated. The message will be addressed to applicable information addressees and will, as a minimum, contain:

(1) Time period of the evaluation.

(2) Test team composition and security clearance status of team members.

(3) Logistic support required for the test team to be provided by the O&M command.

(4) System downtime requirements.

b. On receipt of the test notification message, O&M personnel will perform all required maintenance, optimize system performance, and arrange for logistic support required by the test team to accomplish their test objectives. The O&M command will notify the technical evaluation detachment of the following:

(1) Name and telephone number of the local point of contact for the evaluation.

(2) Status of quarters, rations, and logistic support identified in the test notification message.

(3) Reconfiguration, renovation, or maintenance actions that may be scheduled or in progress that could influence the test results.

c. Prior to the actual evaluation, the individuals responsible for conducting the evaluation will insure that all necessary test equipment and associated connectors are on hand, calibrated, and in good working condition. A check will be made to insure that all forms and data sheets are available and that they are adequate to complete the required report. In addition, the evaluation team leader will prepare a provisional plan for conducting the evaluation.

d. Upon arrival at the station to be evaluated, the team leader will brief the senior C-E O&M commander on the evaluation to be conducted. After the initial briefing, supervisors will be interviewed to determine what problems, if any, are known that could influence completion of the evaluation.

e. The initial facility evaluation should consist of a general walk-through and orientation and a quick review of the facility records, drawings, and operational logs. A suitable working location for the evaluation team will be established in coordination with station personnel. This location must be selected to minimize interference with facility personnel in their daily duties.

2-2. EVALUATION SEQUENCE.

a. The tests listed in chapter 3 are considered the minimum that should be performed on each system. A logical sequence of testing will be accomplished on each system. When performed in an orderly, efficient manner, a facility can be evaluated in a minimum of time. Some procedures in this pamphlet include tutorial information to provide the technician a better understanding of the tests and analysis of the test results.

b. During the evaluation, the test team must examine all facets of the transmission system and its operation to arrive at logical conclusions for problems encountered. Generally, the evaluation will include:

(1) Equipment/materiel. This includes examination of transmission characteristics of the system to determine if it is being influenced by deterioration, induced voltages, or improper operation.

(2) Maintenance. The quality of maintenance, both operator and higher echelon, has a direct bearing on the results of the evaluation. Constructive criticism of the maintenance and recommendations for improvement are highly desirable.

(3) Personnel. The adequacies of manning, training, and supervision at each location must be included in the evaluation, since these factors could influence the test results.

2-3. CONTRIBUTING FACTORS. Additional factors that can contribute to less than quality performance in an HF or radio system are:

a. Dissimilarities of Systems. Many radio systems have been installed over a long period of time, with each installation subject to procurement constraints, availability of funds, and the prevailing technology. The resultant facilities, therefore, preclude the establishment of a single course of corrective action until all problems have been fully identified and documented. Even then, it may be necessary to develop a program of corrective actions tailored to the requirements of a particular installation.

b. Dissimilarities of Installation. The existing HF and radio systems have been installed by a variety of US military, US civilian contractors, foreign nationals, and foreign national contractors. Although factors such as military standards and specifications are employed

to safeguard against nonstandard installations, the resultant systems vary considerably in configuration and installation techniques. This often necessitates the development of a tailored course of corrective action, rather than a single, all encompassing solution.

2-4. DISCREPANCIES. All discrepancies and problem areas that are not corrected during the course of the evaluation are to be fully documented in the report, along with recommended corrective action. These data can then be used to determine the best possible course of corrective action on a site-by-site basis. It is important that the difference between problems and problem symptoms be recognized. Because the noise level on a system between points A and B is above the acceptable standard it does not necessarily mean that the system should be replaced. The reason for excessive noise must be determined. Once this has been determined, a logical course of corrective action can be initiated. The problem may be the result of an improper antenna installation, for which remedy and cost would be much less than for replacing the entire system. The measurement of such parameters as attenuation, noise, and distortion are all symptoms of a problem, not necessarily the problem itself.

2-5. RESPONSIBILITIES. The test team chief will:

a. Supervise the test team activities and insure that all data are collected and analyzed in an effective manner.

b. Provide an entrance briefing to the commander of the evaluated unit, which includes:

(1) A review of the evaluation objectives.

(2) Delineate the immediate and long range goals of the evaluation program.

(3) Tests to be performed, and the purpose of each test.

(4) Logistic support requirements.

c. Insure that all test equipment is accounted for and properly maintained.

d. Provide technical assistance to onsite personnel for improving system performance.

e. Insure that all test equipment, test data forms, and related material are readily available to the test team.

f. Review the technical manuals and technical specifications to become familiar with the equipment/systems to be evaluated.

g. Evaluate all test data, for completeness, accuracy, and correlation with other data. The test team leader will review the total report in detail to verify all data and prepare the performance summary. The comments section of the test cover page (USACC Form 351-R (Test)) will be used for the summary portion of the report.

h. Take every precaution to protect team members and station personnel from the risk of electrical shock or other electrical hazards.

i. At the conclusion of the evaluation, the team chief will give an exit briefing on the results of the evaluation to site personnel and the senior O&M commander. The exit briefing will include, as a minimum:

(1) A summary of the test results in nontechnical terms whenever possible.

(2) A statement of deficiencies noted during the evaluation.

(3) Deficiencies requiring ongoing corrective action by the O&M command, and technical recommendations for necessary actions to improve system performance.

j. In addition to the exit briefing, the team chief will provide a written list to the senior O&M C-E commander of ongoing corrective actions necessary to improve system performance. The O&M commander will be advised that a response to the necessary corrective actions is required upon receipt of the formal test report.

2-6. TYPES OF DATA.

a. Tests are performed to provide a comprehensive and accurate characterization of the system. Through necessity, these tests may be further defined as preliminary or final depending on the corrective actions taken while the evaluation is in progress.

b. The test results will be considered preliminary if it is apparent that remedial action is required to bring the system within requisite performance standards. Once the remedial action has been accomplished the test will be rerun to obtain the final data. In the event remedial action cannot be accomplished while the team is onsite, the preliminary data will be annotated as the final test results, and required follow-on corrective actions will be summarized in the final test report.

c. Sample test forms for recording the test data are included in this pamphlet. These sheets may be extracted and reproduced locally, as required. During the course of the evaluation, it may be necessary to modify or supplement the sample test forms. In completing the data forms, regardless of their final format, the following pertinent points should be observed.

(1) Signing, checking, and verifying the data entries. The test team leader will check and verify as accurate all test results recorded on individual data sheets.

(2) Cover sheet. A cover sheet for each test sequence will be used to summarize the test results and to recommend corrective actions (USACC Form 351-R (Test), figure 2-1).

(3) Absolute meter readings. All measured data will be entered on the data form as absolute (i.e., dbm absolute). All graphical data will be scaled in dbm or other appropriate corrected relative levels.

(4) Test points. The test point used for each test will be annotated on the test data form or cover sheet.

2-7. FINAL TEST REPORT. The final test report will be assembled in two or more volumes depending on the scope of the evaluation. Volume I (parts one and two) will be organized in the format outlined below; paragraph numbers in parenthesis are keyed to the sample test report (app B). Volume II and succeeding volumes will include copies of all test data collected during the evaluation.

a. (1.0) GENERAL. This paragraph will contain the name and geographical location of the station, the unit designation and mailing addresses of the operating agency, the period of evaluation, test team composition, and key personnel contacted.

b. (2.0) SUMMARY OF TEST RESULTS. A narrative summary of the test results, by test number as contained in chapter 3, will include information on the tests conducted and the results of each test. Deviations from expected results should be discussed. Separate subparagraph headings will be used for each performance characteristic discussed.

c. (3.0) OMITTED OR INCOMPLETE TESTS. Tests that are performed or are performed in such a manner to invalidate the test data will be listed in this paragraph and a brief explanation will be given for incomplete or invalid test results.

d. (4.0) CONCLUSIONS. Conclusions will be based on overall performance of the system and will list all discrepancies that were encountered and uncorrected while onsite. Corrective actions accomplished to bring the facility up to performance standards will also be included.

e. (5.0) TECHNICAL RECOMMENDATIONS. Generally, the recommendations contained in this paragraph will follow the conclusions reached as a result of the evaluation. Each recommendation must provide a logical solution to each deficiency. Each solution will require considerable thought and research and must consider the apportionment of personnel, funding, materiel, and time.

f. (6.0) DATA TABULATIONS. Tabulations of data for the radio systems technical evaluation data base will be included in the report. (USACC Form 394-R (Test), figure 2-2.)

<table>
<tr><td colspan="2">TEST COVER PAGE</td><td>☐ PRELIMINARY
☐ FINAL</td><td>DATE</td></tr>
<tr><td colspan="4">DATA SHEET</td></tr>
<tr><td>FACILITY TESTED</td><td colspan="3">DISTANT FACILITY</td></tr>
<tr><td colspan="4">THROUGH FACILITIES:</td></tr>
<tr><td>TEST PERFORMED:
☐ AS SPECIFIED IN TEST PROCEDURES</td><td colspan="3">☐ WITH MINOR MODIFICATIONS
☐ WITH MAJOR MODIFICATIONS (Explain below)</td></tr>
<tr><td colspan="4">COMMENTS</td></tr>
<tr><td colspan="4">STANDARDS/SPECIFICATIONS</td></tr>
<tr><td colspan="4">TEAM LEADER CERTIFICATION</td></tr>
<tr><td>NAME (Typed)</td><td>GRADE</td><td colspan="2">SIGNATURE</td></tr>
</table>

USACC FORM 351-R (TEST)
1 OCT 76

Figure 2-1. Test cover page, data sheet.

STATION AND FACILITY DATA RADIO SYSTEMS (CCR 702-1-3) DATA SHEET	Page Number 1	Number of Pages 7
	STATION FROM	TO

1. Type Terminal . . . . ______
2. VF Channel Data:
   a. Design Capacity . . . . ______
   b. Number of Channels Installed. ______
   c. Number of Channels in Use . . ______
   d. Number of VF Channels . . . . ______
   e. Number of Data Channels . . . ______
   f. Number of Thru Groups . . . . ______
   g. Number of Thru Supergroups. . ______
3. Multiplex Equipment Type. . . . . ______
4. Radio Equipment Type. . . . . . . ______
5. Antenna Type:
   a. Antenna Size (ft):
   (1) Parabolic. . . . . ______
   (2) Near Field Passive . . . . . ______
   (3) Far Field Passive. . . . . . ______
   (4) Other (i.e., Yagi, Vertical) ______
   b. Antenna Gain (db):
   (1) Parabolic. . . . . ______
   (2) Parabolic and Passive. . . . ______
   (3) Far Field Passive. . . . . . ______

USACC Form 394-R (Test)
1 April 1977

Figure 2-2. Station and facility data radio systems, data sheet.

DATA SHEET	Page Number 2	Number of Pages 7
	STATION FROM	TO

(4) Other. . . . . ________

(5) Measured Field Strength (mV) ________

c. Transmission Line:

(1) Type (RG/WR, etc). . . . . . ________

(2) Length (meters). . . . . . . ________

(3) Loss (db). . . . . ________

6. VSWR: Measured:

a. Transmission Line A . . . . . ________

b. Transmission Line B . . . . . ________

7. Transmitter Frequency Assignment (MHz):

a. Transmitter A . . . . ________

b. Transmitter B . . . . ________

8. Transmitter Frequency Accuracy (%):

a. Manufacturer's Specifications ________

b. Measured:

(1) Transmitter A. . . . . ________

(2) Transmitter B. . . . . ________

9. Transmitter Power (watts):

a. Manufacturer's Specifications ________

b. Measured:

(1) Transmitter A. . . . . ________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

DATA SHEET	Page Number 3	Number of Pages 7
	STATION FROM	 TO

(2) Transmitter B. . . . . ________

(3) VSWR (Ratio) . . . . ________

10. Transmitter Deviation (kHz rms)

a. Manufacturer's Specifications ________

b. Measured/Adjusted to:

(1) Transmitter A. . . . . ________

(2) Transmitter B. . . . . ________

(3) Percent Modulation, Normal
Input Drive Level. . . . . . ________

(4) Distortion (%) at Normal
Input Drive Level. . . . . . ________

11. Transmitter Spurious Emissions (dbm/GHz):

a. Manufacturer's Specifications ________

b. Measured:

(1) Transmitter A. . . . . ________

(2) Transmitter B. . . . . ________

12. Transmitter Carrier Suppression:

a. Manufacturer's Specifications ________

b. Measured (dbm). . . . . ________

13. RF Pre-Amplifier Gain and Noise
Figure (db/db):

a. Manufacturer's Specifications ________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

	Page Number 4	Number of Pages 7
DATA SHEET	STATION FROM	TO

b. Measured:

(1) Receiver A . . . . ____________

(2) Receiver B . . . . ____________

14. Total Receiver Noise Figure (db):

a. Manufacturer's Specifications ____________

b. Measured:

(1) Receiver A . . . . ____________

(2) Receiver B . . . . ____________

15. Receiver LO Frequency Accuracy (%):

a. Manufacturer's Specifications ____________

b. Measured:

(1) Receiver A . . . . ____________

(2) Receiver B . . . . ____________

(3) Audio Output (dbm) . . . . . ____________

16. Receiver Frequency Response:

a. Manufacturer's Specifications ____________

b. Measured (kHz). . . . . ____________

17. Receiver Spurious Response:

a. Manufacturer's Specifications ____________

b. Measured (dbm). . . . . ____________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

DATA SHEET	Page Number 5	Number of Pages 7
	STATION FROM	TO

18. Receiver FM Threshold (dbm):

    a. Manufacturer's Specifications ________

    b. Measured:

    (1) Receiver A . . . . ________

    (2) Receiver B . . . . ________

19. Threshold Extension Improvement (db):

    a. Manufacturer's Specifications ________

    b. Measured:

    (1) Receiver A . . . . ________

    (2) Receiver B . . . . ________

20. Receiver IF Bandwidth (MHz):

    a. Manufacturer's Specifications ________

    b. Measured:

    (1) Receiver A . . . . ________

    (2) Receiver B . . . . ________

    (3) Receiver Sensitivity (mV). . ________

    (4) Audio Squelch Limits . . . . ________

21. IF Frequency at Zero Discriminator Output (MHz):

    a. Manufacturer's Specifications ________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

DATA SHEET	Page Number 6	Number of Pages 7
	STATION FROM	TO

b. Measured:

(1) Receiver A . . . . ________

(2) Receiver B . . . . ________

22. Receiver Discriminator Characteristics (% of Non-Linearity):

a. Manufacturer's Specifications ________

b. Measured:

(1) Receiver A . . . . ________

(2) Receiver B . . . . ________

23. Radio Equipment NPR/BNR (db) for RF___ or IF___Loop at___dbm0 Loading:

a. Manufacturer's Specifications ________

b. Measured (TX No___RX No___):

(1) Low_____(kHz). . . . . ________

(2) Mid_____(kHz). . . . . ________

(3) High____(kHz). . . . . ________

(4) RSL During Test (dbm). . . . ________

24. Intermodulation Products (dbm):

a. Manufacturer's Specifications ________

b. Measured Transmitter A. . . . ________

c. Measured Transmitter B. . . . ________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

DATA SHEET	Page Number 7	Number of Pages 7
	STATION FROM	TO

25. Station Ground (ohm):

a. Standard. . . . . ____________

b. Measured. . . . . ____________

Figure 2-2. Station and facility data radio systems, data sheet. (continued)

CHAPTER 3

TEST PROCEDURES FOR RADIO SYSTEMS TECHNICAL EVALUATION

3-1. DISCUSSION. The tests in this pamphlet are designed to determine the transmission characteristics and functional capabilities of the radio equipment and system and to identify problem areas that can affect communications quality.

3-2. PERFORMANCE LEVELS. Prior to performing some tests, predicted performance levels should be calculated and recorded on the test cover sheet to which the calculations apply.

3-3. TEST SEQUENCE.

a. A logical sequence of testing will be accomplished on each system to be evaluated. A listing of the minimum tests to be performed is shown in figure 3-1. This list is not all inclusive and test teams may need to develop additional tests based on the equipment and systems being evaluated.

b. As the individual test sequences are completed, all deviations from the expected results and specifications should be annotated on the test data forms. When possible, the specific cause of the irregularity should be identified, along with the recommended corrective action. If the necessary corrective action is too complex or time consuming to accomplish while onsite, the problem must be fully documented so that follow-on corrective action can be accomplished.

c. Because of the general nature of these procedures, variations of the test procedures or test equipment setup may be necessary depending on the radio equipment under test or the type of test equipment available. Personnel using these procedures must be technically qualified and proficient to adapt these procedures to various radio equipment encountered during an evaluation. Technically skilled personnel are necessary so the test teams can determine the operational performance capability of the equipment and systems and arrive at sound recommendations supported by technical documentation. The block diagrams used in these procedures are intended to depict narrowband HF radios in general and are not intended to represent any specific type or make of radio equipment.

TEST NUMBER	TEST TITLE	CHAPTER
1	Transmitter RF Output Power versus Frequency	4
2	Transmitter Two-Tone Intermodulation Distortion	5
3	Transmitter Modulation Characteristics	6
4	Transmitter Frequency Modulation	7
5	Transmitter Carrier Suppression	8
6	Transmitter Carrier Frequency Accuracy	9
7	Transmitter Spurious Emissions	10
8	Transmitter Output Power and Voltage Standing Wave Ratio (VSWR)	11
9	Antenna VSWR and Transmission Line Loss	12
10	Radio FM Receiver Frequency Response	13
11	Receiver FM Quieting, AGC, and Audio Output Characteristics	14
12	Receiver Selectivity/IF Bandpass	15
13	Receiver Spurious Response	16
14	Receiver Sensitivity, AGC, Audio and Squelch (AM Radio)	17
15	Radio Service Area RF Field Strength	18
16	Station Ground Measurement	19

Figure 3-1. Radio technical evaluation procedures (RTEP) tests.

CHAPTER 4

RTEP TEST 1, TRANSMITTER RF OUTPUT POWER VERSUS FREQUENCY (TUNABLE TRANSMITTERS ONLY)

4-1. PURPOSE. The purpose of this test is to determine the RF power output of an HF transmitter over its frequency range. This test applies only to tunable transmitters. For independent sideband (ISB) equipment, this test should be accomplished for all operational sidebands.

4-2. TEST EQUIPMENT.

a. Audio signal generator.

b. AC voltmeter.

c. Wattmeter (dummy load).

d. DC voltmeter.

e. Frequency counter.

f. Coaxial attenuators.

4-3. TEST PROCEDURES.

a. Establish the test setup shown in figure 4-1.

b. Insure that the output of the power amplifier is connected to the dummy load to avoid interfering with other stations.

c. Tune the transmitter to the lowest operational frequency and set for upper sideband operation.

d. Adjust the output of the signal generator for 1 kHz at the nominal drive level. The nominal drive level may be determined from TMs, station level diagrams or appropriate manuals.

e. Key the transmitter and measure the automatic load control (ALC) voltage and the power output. Record these parameters on USACC Form 395-R (Test), figure 4-2.

f. Unkey the transmitter.

g. Repeat steps 4-3c through 4-3f for:

(1) All operational frequencies.

(2) Enough additional frequencies between 3 and 30 MHz to adequately show the RF power output capabilities of the transmitter. At least three frequencies should be tested within the range of 3-6, 6-12, 12-18, 18-24, and 24-30 MHz.

h. Return the equipment to its normal configuration and complete the data sheet, USACC Form 395-R (Test), figure 4-2.

i. Plot the data on graph paper, USACC Form 396-R (Test), figure 4-3.

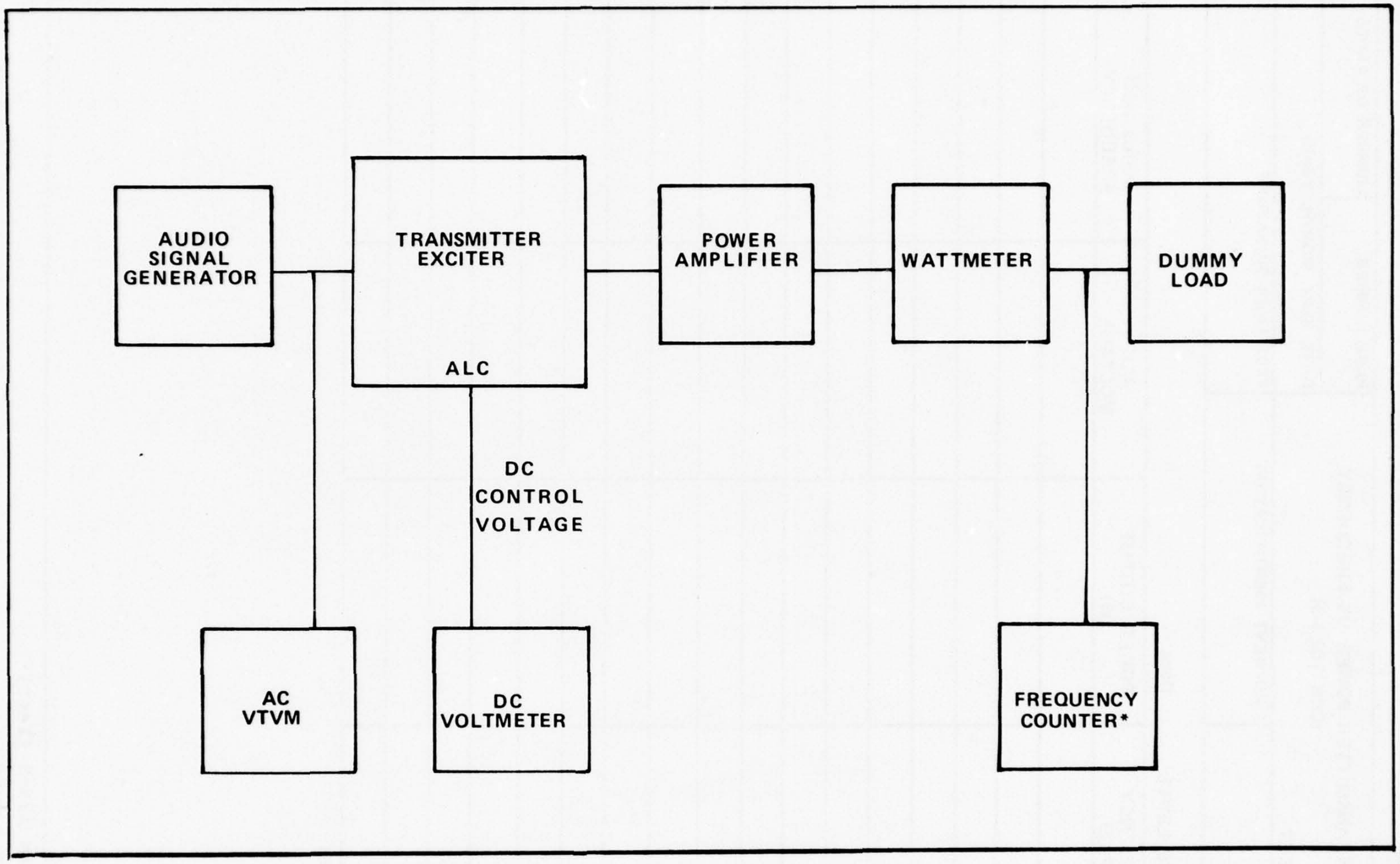


Figure 4-1. Transmitter RF output power and frequency, test setup.

TRANSMITTER POWER VS FREQUENCY (CCR 702-1-3) DATA SHEET		PAGE NUMBER	NUMBER OF PAGES
		DATE (DAY, MONTH, YEAR)	
LOCATION	EQUIPMENT IDENTIFICATION	TEST ENGR SIGNATURE	

INPUT TONE LEVEL ______DBM

FREQUENCY (MHZ)	POWER OUTPUT (W)	ALC VOLTAGE	MEASURED FREQUENCY
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			

COMMENTS:

USACC Form 395-R (Test)
1 April 1977

Figure 4-2. Transmitter power versus frequency, data sheet.

GENERAL PURPOSE GRAPH PAPER (CCR 702-1-3)			PAGE NUMBER	NUMBER OF PAGES
DATA SHEET			DATE (DAY, MONTH, YEAR)	
LINK NO.	STATION UNDER TEST	DISTANT STATION	TEST ENGR SIGNATURE	
TITLE OF PERFORMANCE PLOTTED				TEST NO.

USACC Form 396-R (Test)
1 April 1977

Figure 4-3. General purpose graph paper, data sheet.

CHAPTER 5

RTEP TEST 2, TRANSMITTER TWO-TONE INTERMODULATION DISTORTION

5-1. GENERAL. This test applies to all technical evaluations of single sideband HF radio systems performed under the technical evaluation program. The test is divided into two parts; first, the intermodulation distortion (IMD) is measured with the transmitter terminated into its characteristic impedance; second, the IMD is measured with the transmitter connected to its normal antenna while in service.

5-2. TEST EQUIPMENT.

a. DC voltmeter.

b. AC voltmeter.

c. Audio generator

d. Coaxial attenuators.

e. Wattmeter.

f. Spectrum analyzer.

g. Dummy load.

h. Camera, oscilloscope.

5-3. INTERMODULATION DISTORTION WITH TRANSMITTER TERMINATED.

a. Establish the test setup as shown in figure 5-1. Insure that the transmitter RF output power does not exceed the design capability of the dummy load.

b. Determine the nominal audio input level to the transmitter exciter from station level diagrams, technical manuals, or manufacturer's specifications.

c. Connect the signal generator to the exciter input and adjust the composite output level of the generator to a level at least 15 db below the nominal exciter input level. Set the generator to produce a 1 kHz and 1.4 kHz tone, with both tones of equal amplitude.

d. Verify the tuning of the exciter and transmitter and tune for full rated RF output power.

e. Record the following information on test data form, USACC Form 404-R (Test), figure 5-2.

(1) Audio input level (dbm0).

(2) ALC voltage (vdc).

(3) Power output (watts).

(4) Third order intermodulation distortion (IMD) level as observed on the spectrum analyzer. Observe the RF spectrum for any spurious emissions and provide appropriate comments on test data.

(5) Increase the audio input level in 5 db steps to a level of +10 dbm0 and record the data specified in paragraph 5-3e above. Perform a measurement at the manufacturer's design input level so that a comparison can be made between design parameters, operating levels, and the resultant intermodulation products when the transmitter is overdriven. To preclude damage to the equipment, exercise care when applying an input tone to the transmitter/exciter which exceeds the manufacturer's design specification.

(6) Return the equipment to its normal operating configuration and complete the test data sheet, USACC Form 404-R (Test).

5-4. INTERMODULATION DISTORTION WITH EQUIPMENT IN NORMAL OPERATING CONFIGURATION. This part of the test is accomplished with the transmitter/exciter in its normal in-service configuration. This test is used to determine the presence of intermodulation products which may result from the mixing of other transmitters operating at the same time in the general proximity of the equipment being evaluated. Third order harmonic products are described as 2 P-Q or 2 Q-P where Q and P are any two frequencies that may be involved.

a. Establish the test setup as shown in figure 5-1.

b. Tune the spectrum analyzer to a selected frequency that has been determined to be a possible source of intermodulation interference.

c. With the product frequency displayed on the spectrum analyzer cathode ray tube (CRT), measure the amplitude of the signal (the level of the harmonic) as read directly from the spectrum analyzer's graticule.

d. Photograph each intermodulation product that is of a sufficient level to cause interference.

e. Summarize the test results on the test data cover sheet, USACC Form 351-R (Test), figure 2-1, and mount photographs on USACC Form 397-R (Test), figure 5-3. On all photographs and data forms, be sure to identify the frequency used and levels observed.

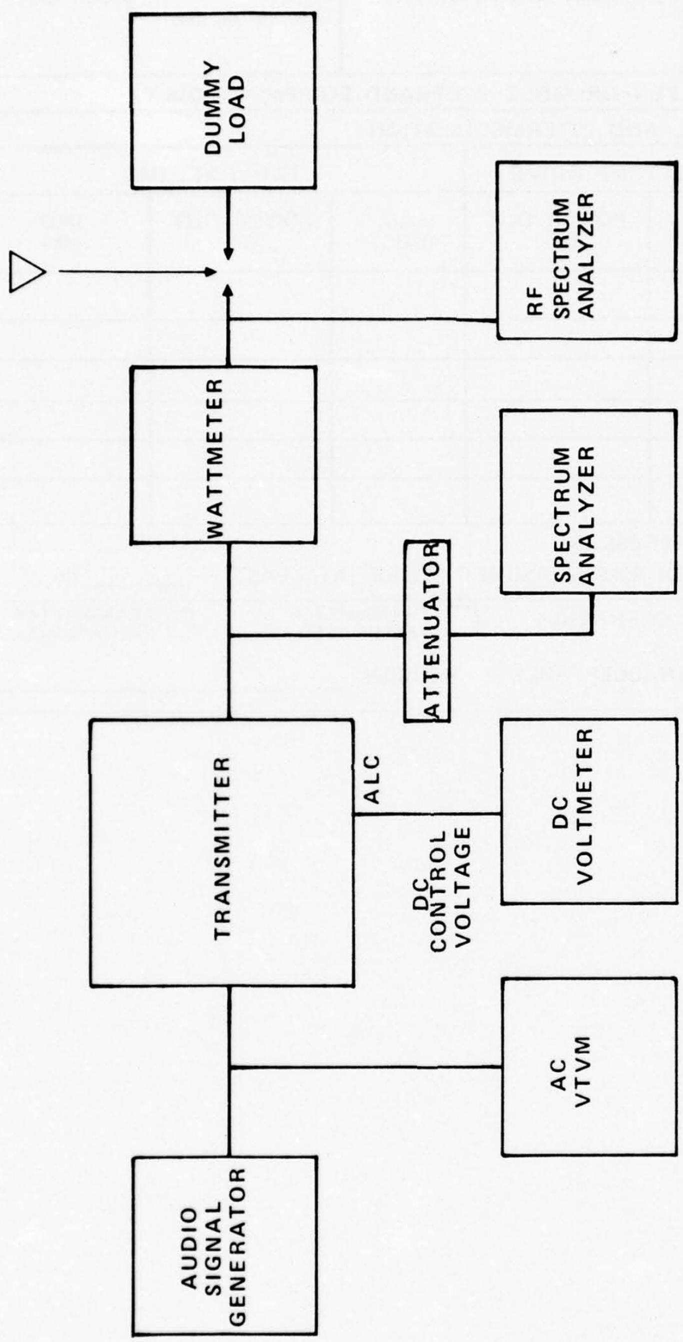


Figure 5-1. Transmitter two-tone intermodulation distortion, test setup.

DATA SHEET

TRANSMITTER MEASUREMENTS
(CCR 702-1-3)

PAGE ___ OF ___ PAGES

FACILITY	EQUIPMENT IDENTIFICATION	DATE (day, month, year)	TECH INIT

TRANSMITTER PERFORMANCE (SIDEBAND EQUIPMENT ONLY)

1. TRANSMITTER DRIVE LEVEL AND INTERMODULATION

AUDIO INPUT (dbmO)	SINGLE TONE DRIVE		TWO TONE IMD		
	ALC (VDC)	POWER OUT (W)	ALC (VDC)	POWER OUT (W)	IMD (db)
-15					
-10					
- 5					
0					
+5					
+10					

2. TRANSMITTER CARRIER SUPPRESSION

CARRIER SUPPRESSION WAS MEASURED TO BE (AT LEAST) ______ db

3. TRANSMITTER KEYING/VOX OPERATION ☐ TRANSMITTER TERMINATED ☐ TRANSMITTER OPERATIONAL

☐ ACCEPTABLE ☐ UNACCEPTABLE REASON: ______________________

4. COMMENTS:

USACC Form 404-R (Test)
1 April 1977

Figure 5-2. Transmitter measurements, data sheet.

DATA SHEET

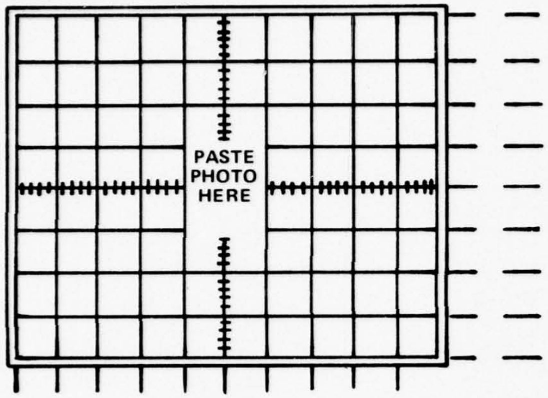
SPECTRUM PHOTOGRAPHS
(CCR 702-1-3)

PAGE ____ OF ____ PAGES

DATE (day, month, year)

LINK NO.	STATION UNDER TEST	TEST NO.	TEST ENGR SIGNATURE

PHOTO TITLE:



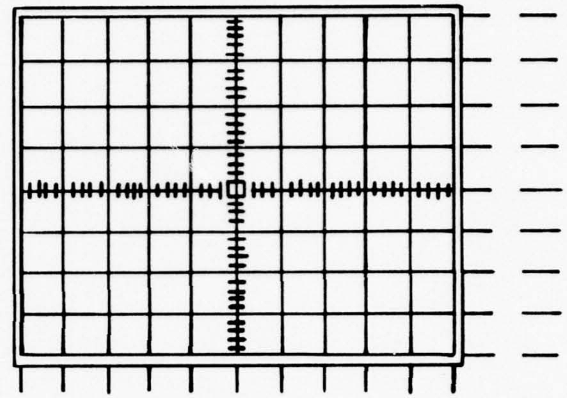
FREQUENCY

ABSOLUTE RESPONSE LEVEL (dbm)

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:



FREQUENCY

ABSOLUTE RESPONSE LEVEL (dbm)

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:

EXTERNAL PHOTO SCALE MARKINGS:

1. Clearly label external bottom "Frequency" scale with exact frequency values.
2. Clearly label the "absolute Response Level" in dbm on the external right hand vertical axis.
3. Identify any special signals of significance.

FREQUENCY

ABSOLUTE RESPONSE LEVEL (dbm)

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE: ☐LOG ☐LIN ☐SQ LAW

PHOTO TITLE:

PHOTO INSTRUCTIONS:

1. Photos must have good black-white contrast. Signals and graticule scale lines must be clearly identified. Photo quality must be sufficient to allow complete page photo offset reproduction.
2. Trim all photos to fit blocks provided.
3. Paste on all photos with rubber cement.

FREQUENCY

ABSOLUTE RESPONSE LEVEL (dbm)

DISPERSION:/DIV

VIDEO FILTER ☐IN ☐OUT RESPONSE ☐LOG ☐LIN ☐SQ LAW

USACC Form 397-R (Test)
1 April 1977

Figure 5-3. Spectrum photographs, data sheet.

CHAPTER 6

RTEP TEST 3, TRANSMITTER MODULATION CHARACTERISTICS

6-1. GENERAL. The purpose of this test is to measure and evaluate the modulation characteristics (frequency response, distortion, and limiting) of high frequency amplitude modulated radio systems. The distortion and limiting tests may be accomplished simultaneously to minimize system outage time. The percentage of modulation can be interpreted in terms of detected level to reduce the test time, since the detected level is proportional to the percentage of modulation being applied. The clearness of intelligibility of any modulated carrier depends on three factors which are directly related to nonlinearities in the transmitter. Briefly, these three factors are defined as:

a. Frequency Response. Measure of RF power versus the percentage of modulation being applied.

b. Limiting. Restricting or controlling the amplitude of the audio signal to a transmitter so that interfering noise can be kept to a minimum.

c. Distortion. Undesirable change in the waveform of the signal. Distortion can result from overdriving the transmitter circuitry. Some forms of distortion are phase, intermodulation, and harmonic.

6-2. TEST EQUIPMENT.

a. RF detectors.

b. RF wattmeter (dummy load).

c. Camera.

d. Audio frequency generator (part of TMS).

e. RMS voltmeter (part of TMS).

f. Isolation transformer.

g. Coaxial attenuators.

h. Distortion analyzer.

i. Spectrum analyzer.

j. Oscilloscope.

k. Modulation meter.

6-3. TEST PROCEDURES.

a. Percentage Modulation Versus Peak-to-Peak/RMS Voltage.

(1) Establish the test setup as shown in figure 6-1.

(2) Apply 30, 50, 70, and 90 percent modulation to the transmitter while measuring the results with the oscilloscope or a true route mean square (RMS) voltmeter. The percentage of modulation being applied may be determined from the oscilloscope using the formula illustrated in figure 6-2. The peak-to-peak valve obtained from the oscilloscope may prove more useful and easier to use than the rms valve, especially when changing the modulating frequency.

(3) Plot the test data on USACC Form 396-R (Test), figure 4-3; this represents the percentage of modulation versus the peak-to-peak voltage obtained from the detected waveform. This data will make the limiting and frequency response tests easier to analyze.

b. Modulation or Limiting Test.

(1) Establish the test setup as shown in figure 6-3.

(2) Adjust the signal generator output to initially establish a transmitter modulation reference of 10 percent. Increase the audio input to the transmitter in steps, recording the audio input level, and percent of modulation until further input to the transmitter fails to provide an increase in the percentage of modulation. This established the limiting point of the transmitter. If there is an external limiting control available, measurement of the various limiting levels should be accomplished. Refer to the applicable technical manual or manufacturer's specifications to insure that the limiting controls are properly adjusted.

(3) Complete the test data elements shown on USACC Form 398-R (Test), figure 6-4.

c. Transmitter Frequency Response.

(1) Establish the test setup shown in figure 6-3.

(2) Adjust the audio generator output for 1 kHz at -15 dbm0. Apply this signal to the transmitter input, note and record the percentage of modulation as observed on the oscilloscope. Increase the audio input frequency until the percent modulation begins to decrease. Record the frequency at which this occurs on USACC Form 398-R (Test). Continue increasing the audio input frequency until the percent modulation drops to half that obtained at the 1 kHz reference frequency. This represents below 1 kHz until the percent modulation just begins to drop. Record this frequency on USACC Form 398-R (Test). Continue decreasing the input

frequency until the modulation percentage drops to half that obtained at the 1 kHz reference frequency. Record this data on USACC Form 398-R (Test).

(3) Repeat the above steps for -6 dbm0 and 0 dbm0 input or any selected level, noting the input frequency, audio input level, and percent modulation observed at the various input levels and frequency.

(4) The sidetone level and distortion may also be measured and recorded during the preceeding steps by using an RMS voltmeter and distortion analyzer.

(5) Complete all data elements on USACC Form 398-R (Test) and summarize the test results on USACC Form 351-R (Test).

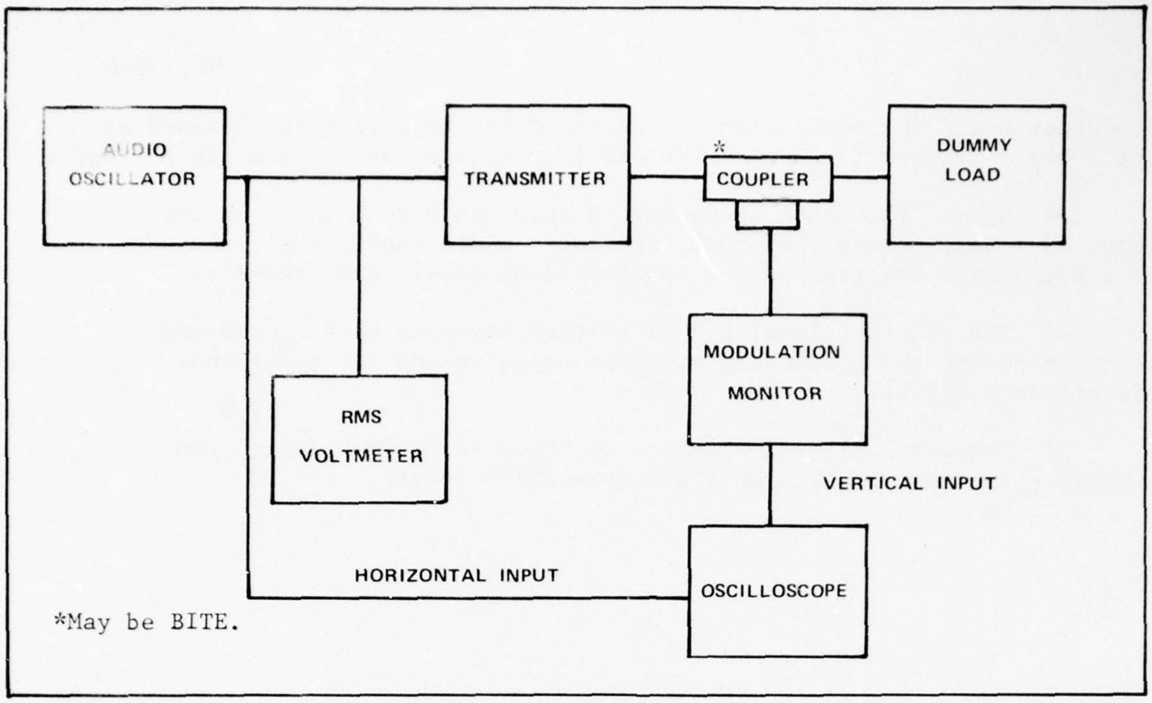
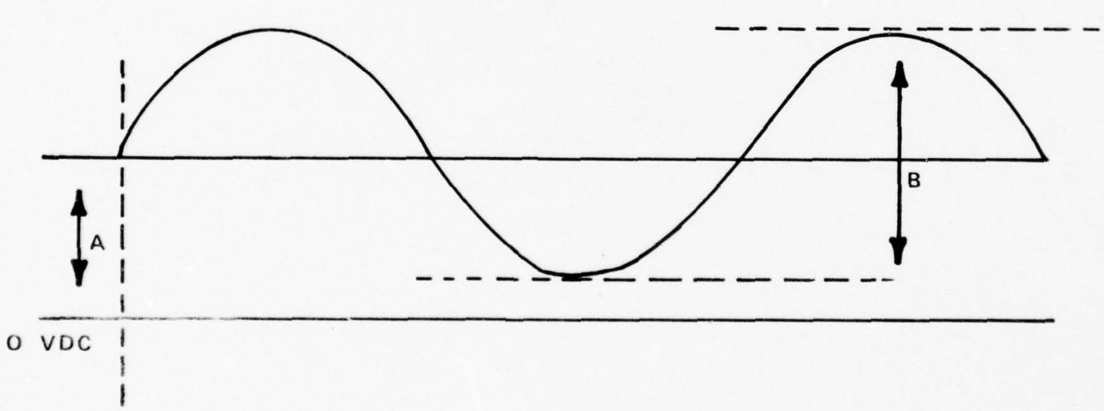
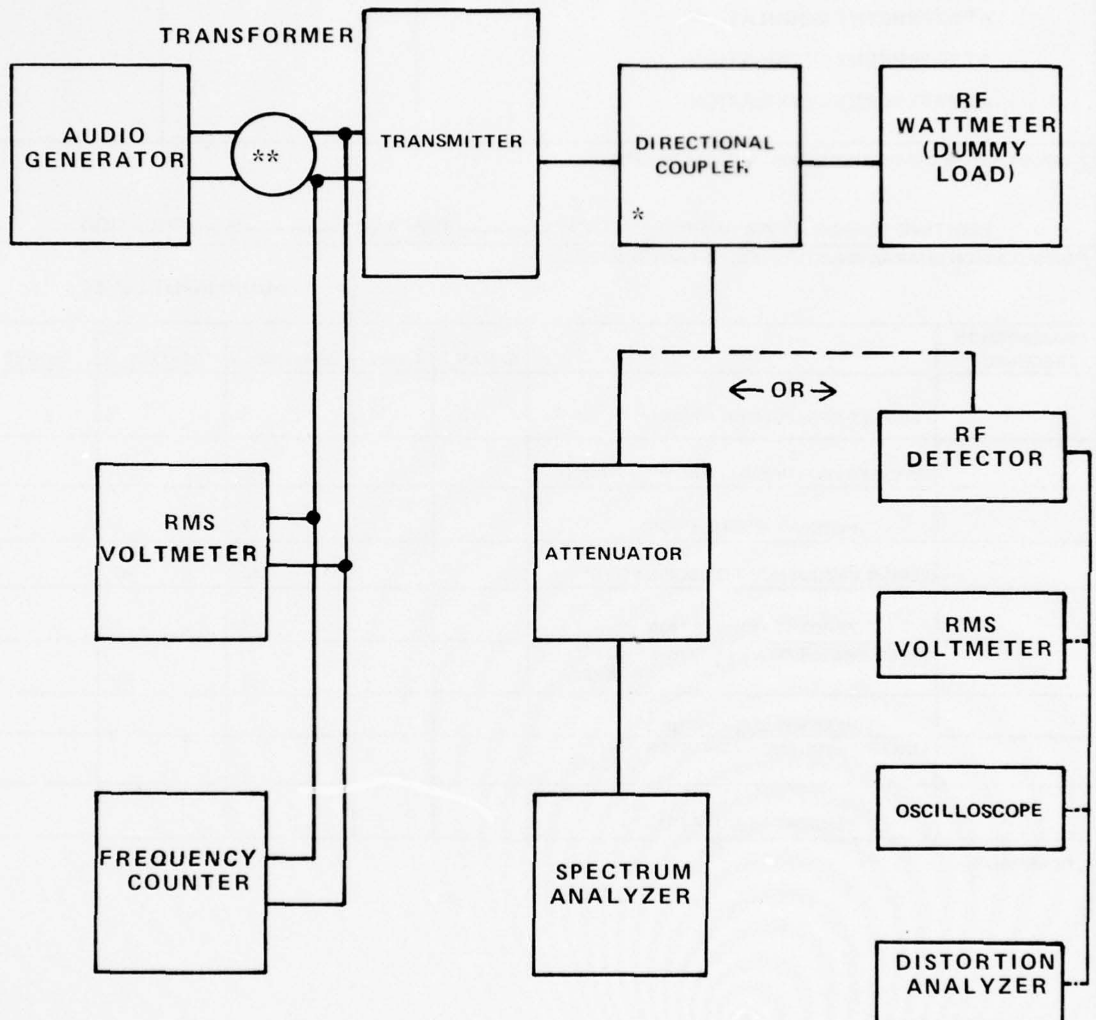


Figure 6-1. Modulation characteristics, test setup.



$$\% M = \frac{E_{MAX} - E_{MIN}}{E_{MAX} + E_{MAX}} (100)$$

Figure 6-2. Detected waveform.



*May be built-in test equipment. If not available, loosely couple TMDE for low RF output.

**Not required if generator output matches the transmitter input impedance.

Figure 6-3. Limiting, distortion, and frequency response, test setup.

TRANSMITTER MODULATION MEASUREMENTS (CCR 702-1-3)		PAGE NUMBER	NUMBER OF PAGES
		DATE (DAY, MONTH, YEAR)	
DATA SHEET			
LOCATION	EQUIPMENT IDENTIFICATION	TEST ENGR SIGNATURE	

1. MODULATION CHARACTERISTICS - DISTORTION AT 700 HZ	DISTORTION (%)	PEAK-TO-PEAK (VOLTS)
AT 30 PERCENT MODULATION:		
AT 50 PERCENT MODULATION:		
AT 70 PERCENT MODULATION:		
AT 90 PERCENT MODULATION:		

2. MODULATION CHARACTERISTICS - AVOID LIMITING

LIMITING BEGINS AT AN AUDIO LEVEL OF ______ DBM AND ______ % MODULATION

3. MODULATION CHARACTERISTICS - FREQUENCY RESPONSE

TRANSMISSION FREQUENCY		E-MAX	E-MIN	AUDIO INPUT LEVEL -15 DBM0	-10 DBM0	0 DBM0
	PERCENT MODULATION AT 1 KHZ			%	%	%
	UPPER FREQUENCY AT 1 DB DOWN POINT			HZ	HZ	HZ
	PERCENT MODULATION			%	%	%
	LOWER FREQUENCY 1 DB DOWN POINT			HZ	HZ	HZ
	PERCENT MODULATION			%	%	%
	UPPER FREQUENCY 3 DB DOWN (HALF POWER)			HZ	HZ	HZ
	PERCENT MODULATION					
	LOWER FREQUENCY 3 DB DOWN (HALF POWER)					
	PERCENT MODULATION					

4. COMMENTS:

USACC Form 398-R (Test)
1 April 1977

Figure 6-4. Transmitter modulation measurements, data sheet.

CHAPTER 7

RTEP TEST 4, TRANSMITTER FREQUENCY MODULATION

7-1. PURPOSE.

a. The purpose of this test is to check the modulation level and frequency response of a single channel FM transmitter. These parameters are a form of modulation in which instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating signal. The modulation level must be maintained within specified limits to preclude transmission at unauthorized frequencies and to insure that the transmitted signal is intelligible.

b. Modulation of an FM transmitter is normally expressed in terms of frequency deviation (kHz) for 100 percent modulation.

c. Multichannel FM systems are to be evaluated in accordance with the procedures contained in CCP 702-1.

7-2. TEST EQUIPMENT.

a. Audio signal generator.

b. AC voltmeter.

c. FM deviation meter.

d. Attenuators, coaxial connectors, as required.

e. RF spectrum analyzer.

f. Frequency counter.

7-3. TEST PROCEDURES.

a. Establish the test setup as shown in figure 7-1. The transmitter output is connected through an attenuator to the input of the modulation deviation meter using a coaxial cable. A dummy load is connected to the transmitter under test to minimize interference with other communications service.

b. Connect the audio signal generator to the transmitter input and adjust the generator to a frequency of 1,000 Hz.

c. Set the output level of the test oscillator to the optimum input value as specified by the technical manual or manufacturer's specifications. This optimum level should be that level required to

produce 100 percent modulation. This level, along with the 1,000 Hz input frequency, becomes the reference point for completing USACC Form 399-R (Test), figure 7-2. Vary the audio input from +5 to -5 db from the referenced input level while observing the percentage of modulation as indicated on the deviation meter.

d. Measure the peak-to-peak frequency deviation as read on the deviation meter. Record this information on USACC Form 399-R (Test).

e. Observe the modulated RF output with the spectrum analyzer while performing the above tests. Photograph any anomolies, mount the photographs on USACC Form 397-R (Test), and summarize the data on test cover form USACC Form 351-R (Test).

f. If the FM transmitter is used on more than one frequency, repeat the above steps for each assigned frequency.

g. Plot a curve of the test results on USACC Form 399-R (Test).

h. Return the transmitter to its normal operating configuration and summarize all test data results on test cover page, USACC Form 351-R (Test).

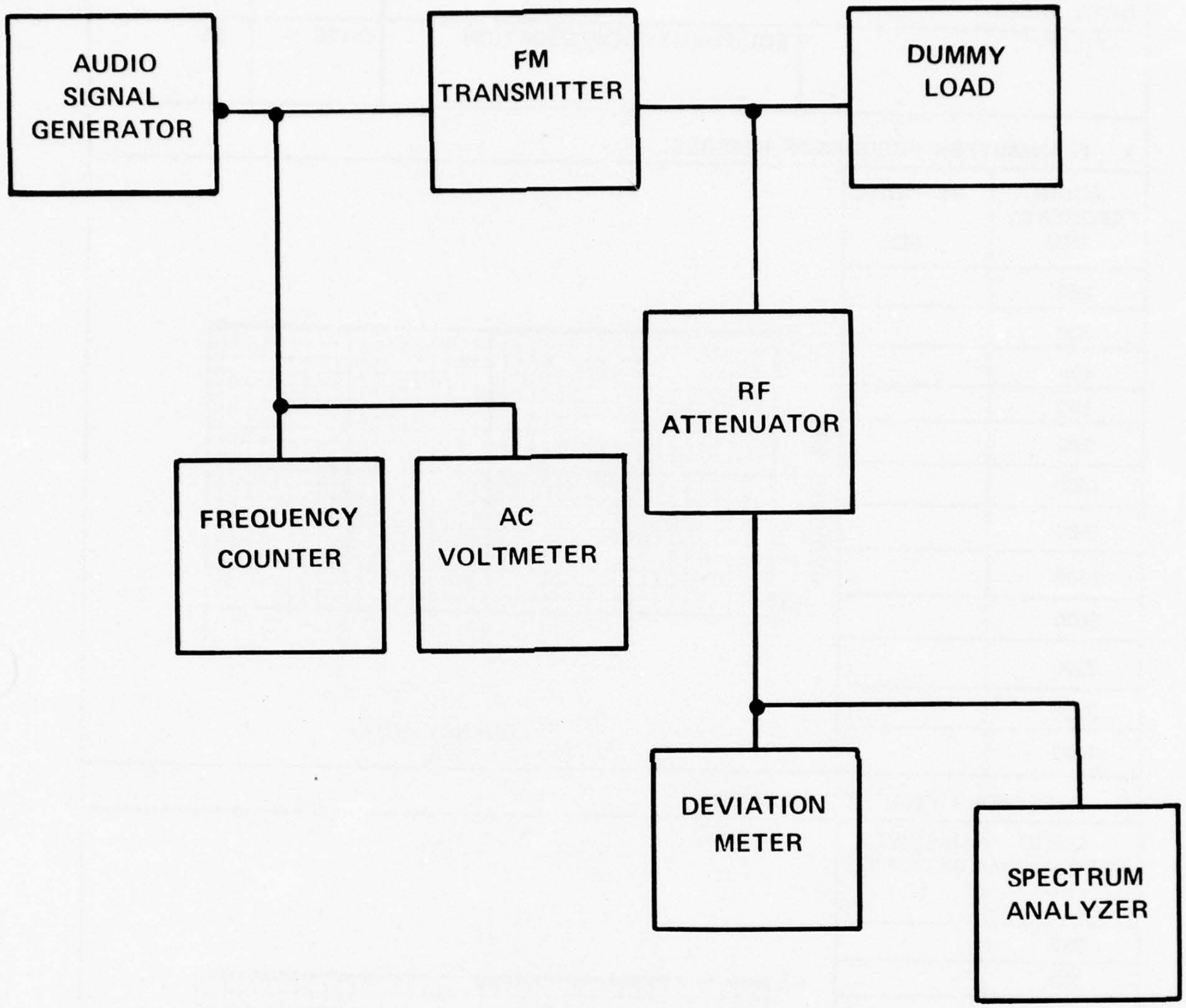


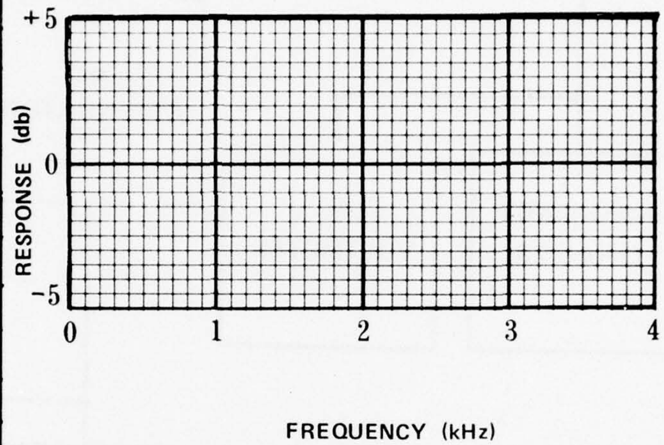
Figure 7-1. Transmitter frequency modulation, test setup.

FREQUENCY RESPONSE
(CCR-702-1-3)

DATA SHEET		PAGE NO.	NO. OF PAGES
FACILITY	EQUIPMENT IDENTIFICATION	DATE	BY

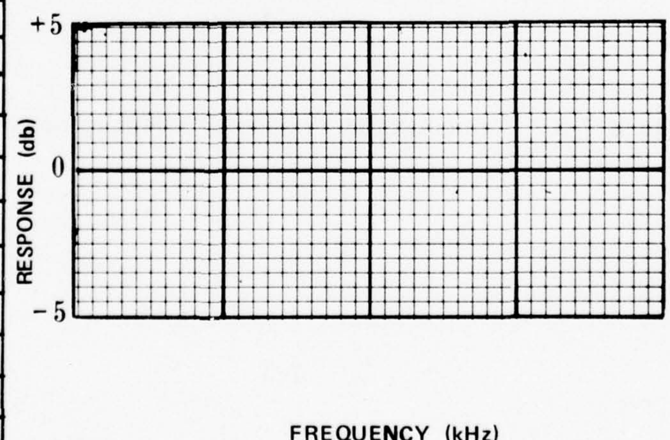
1. TRANSMITTER FREQUENCY RESPONSE

AUDIO FREQUENCY (Hz)	RESPONSE (db)
250	
300	
400	
500	
700	
1000	
1500	
2500	
3000	
3500	
3750	
4000	



2. RECEIVER FREQUENCY RESPONSE

AUDIO FREQUENCY (Hz)	RECEIVER RESPONSE (db)
250	
300	
400	
500	
700	
1000	
1500	
2500	
3000	
3500	
3750	
4000	



USACC Form 399-R (Test)
1 April 1977

Figure 7-2. Frequency response, data sheet.

CHAPTER 8

RTEP TEST 5, TRANSMITTER CARRIER SUPPRESSION

8-1. PURPOSE.

a. The purpose of this test is to measure the carrier suppression capabilities of single sideband and independent sideband (ISB) transmitting equipment.

b. Independent-twin sideband transmitters normally have a built-in variable control that can be used to insert or remove the carrier. This control may be variable from 0 percent to a maximum of 100 percent carrier level. During operation of ISB equipment, common practice has been to use approximately 20 percent carrier in order to provide a tracking signal for the sideband converter. In older equipment, this was necessary because of instabilities in the transmit and receive oscillator circuits. With modern equipment, the oscillators are synthesized and provide reliable service without carrier insertion.

c. Single channel sideband equipment operates predominately with maximum suppression of the carrier. This provides more effective talk power in the upper or lower sideband selected as the mode of operation.

8-2. TEST EQUIPMENT.

a. Spectrum analyzer.

b. Variable attenuators.

c. Directional coupler (may be part of built-in test equipment).

d. Dummy load.

e. DC voltmeter.

f. Frequency counter.

8-3. TEST PROCEDURES.

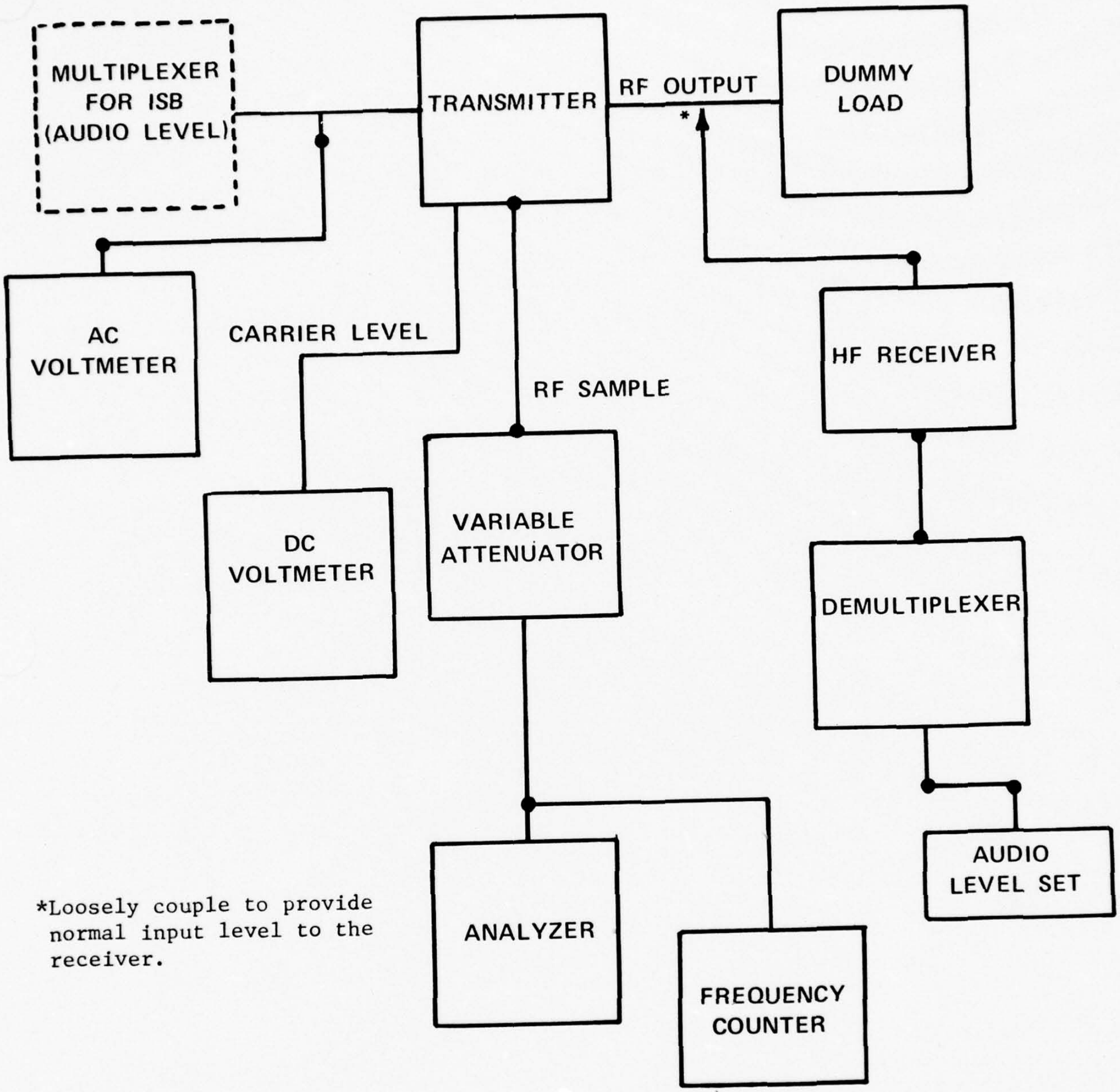
a. Establish the test configuration shown in figure 8-1.

b. Insert maximum carrier level on those transmitters where the carrier level can be controlled.

c. With maximum carrier inserted, establish this as the reference level on the spectrum analyzer.

d. Adjust the variable attenuator until a convenient reference has been established.

e. Once the reference level has been obtained, adjust the equipment carrier level control for minimum carrier insertion. Record the maximum and minimum carrier insertion levels on the test cover page, USACC Form 351-R (Test).



*Loosely couple to provide normal input level to the receiver.

Figure 8-1. Transmitter carrier suppression, test setup.

CHAPTER 9

RTEP TEST 6, TRANSMITTER CARRIER FREQUENCY ACCURACY

9-1. PURPOSE.

a. The purpose of this test is to determine the frequency accuracy of an AM, SSB, or FM transmitter at its operating frequencies. Frequency accuracy is expressed as a percentage of the assigned frequency and must be maintained to prevent interference to adjacent emitters and to achieve frequency compatibility with the associated receiving equipment.

b. The test may be repeated over an extended period of time with readings taken at selected intervals to provide an indication of the stability of the local frequency generating oscillator. These readings can be performed manually, however, the preferred method is to use a calculator controlled frequency counter which provides a more accurate indication of the transmitter stability.

9-2. TEST PROCEDURES. This procedure has two parts. Part one is the preferred method of measuring the frequency accuracy and part two is an alternate method that may be required on some equipment.

a. Frequency Accuracy Measurement (Preferred Method).

(1) Connect the equipment as shown in figure 9-1. Consult the technical manual or manufacturer's literature to obtain the test point designation and level of RF appearing at the test point. Record this information on USACC Form 400-R (Test), figure 9-2.

NOTE: Insure that the RF level at the selected test point does not exceed the input to the frequency counter. Most RF frequency counters have a 50 ohm input impedance, therefore, insure that the TLP is compatible with the frequency counter characteristics.

(2) Allow approximately 30 minutes for the test equipment to warm up.

(3) Where applicable, adjust the transmitter equipment as follows:

(a) Switch the TX/RX switch to TX.

(b) Insert maximum carrier for SSB equipment.

(c) Remove all audio input levels.

(4) With the RF frequency counter, measure and record the transmitter output frequency on USACC Form 400-R (Test), figure 9-2.

(5) Determine the transmitter carrier - frequency accuracy from the following equation:

$$S = \frac{Fc - Fm}{Fc} \times 100$$

Where: S = transmitter carrier frequency accuracy expressed in percentage.

Fc = assigned carrier frequency of the transmitter.

Fm = measured value of carrier frequency of the transmitter.

Example:

Let Fc = 300 MHz

Fm = 300.005 MHz

$$S = \frac{300 - 300.005}{300} \times 100 = \frac{0.005}{300} \times 100 = 0.002\%$$

(6) A minimum of 5-minutes sampling should be taken at 15-second intervals to provide an accurate percentage of frequency accuracy.

(7) Repeat the above tests for all authorized operating frequencies.

b. Frequency Accuracy (Alternate Method).

(1) On some systems it may be necessary to measure the local oscillator frequency accuracy and translate this information into the final output frequency.

(2) Connect the test equipment as shown in figure 9-1.

(3) Repeat the steps in paragraph 9-2a(2) through 9-2a(7)(d) above.

c. Record Test Data. Record all test data on USACC Form 400-R (Test) and summarize the test results on the test cover page, USACC Form 351-R (Test).

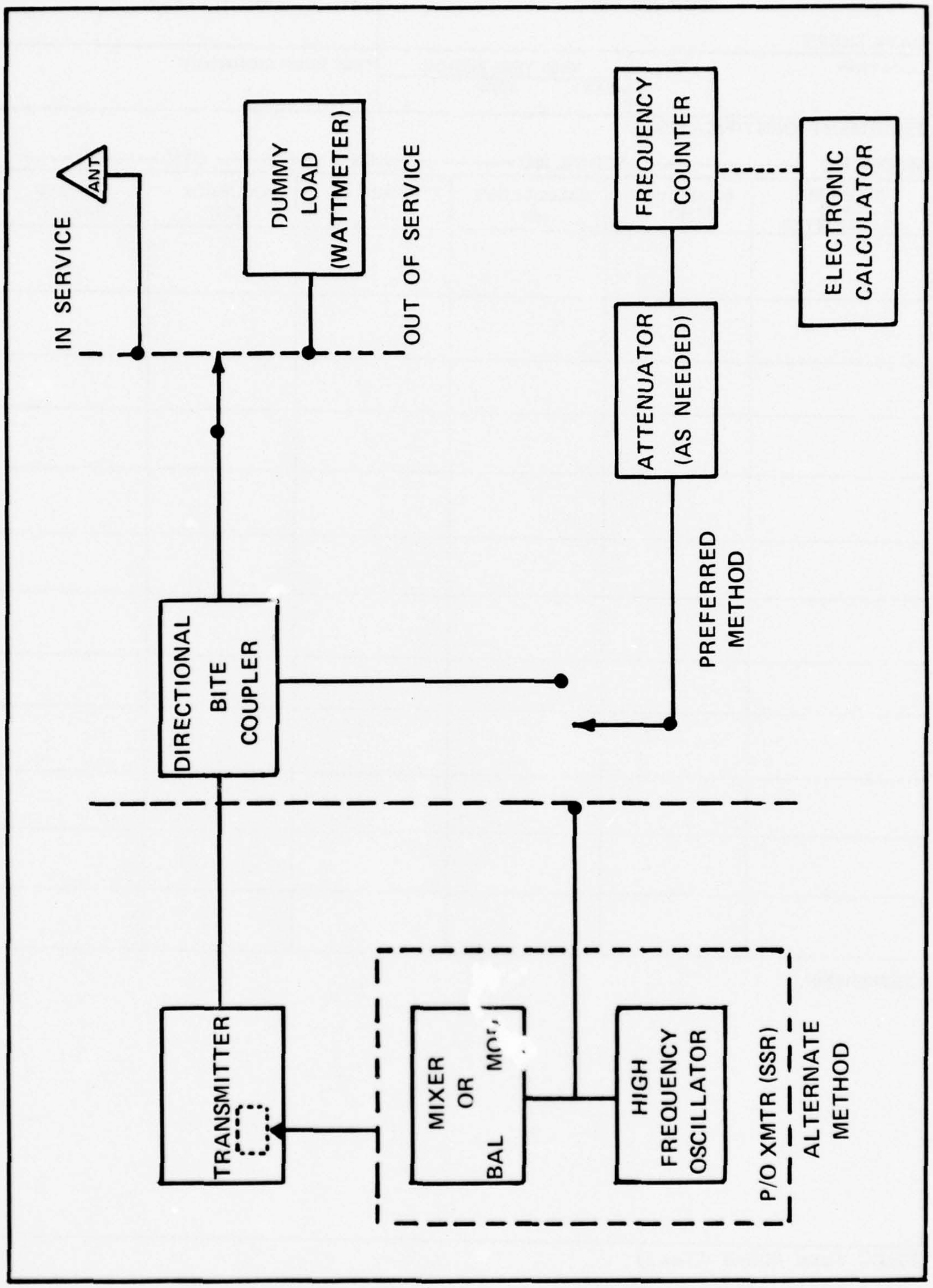


Figure 9-1. Transmitter carrier frequency accuracy, test setup.

TRANSMITTER FREQUENCY ACCURACY (CCR 702-1-3) DATA SHEET		PAGE NUMBER	NUMBER OF PAGES
		DATE (DAY, MONTH, YEAR)	
LOCATION	TEST TIME PERIOD START Z STOP Z	TEST ENGR SIGNATURE	

EQUIPMENT IDENTIFICATION:

MODEL NO ______ SERIAL NO ______ MFG ______ QTY ______

FREQUENCY (MHZ) TRANSMITTER	MEASURED (FMD)	CALCULATED (S)	REQUIRED (FC)	ACCURACY (%)	SAMPLES TAKEN

COMMENTS:

USACC Form 400-R (Test)
1 April 1977

Figure 9-2. Transmitter frequency accuracy, data sheet.

CHAPTER 10

RTEP TEST 7, TRANSMITTER SPURIOUS EMISSIONS

10-1. PURPOSE.

a. The purpose of this test is to measure and evaluate spurious emissions that may be generated within the transmitter equipment due to nonlinearities, maladjustments, or through some form of heterodyning. Spurious emissions are undesirable since they can cause interference or distortion at the distant receiver and degrade the communications quality. Additionally, these undesired emissions can cause interference to other communications transmission services.

b. This test is divided into three parts:

(1) Single tone modulated.

(2) Input signal terminated.

(3) Transmitter white noise loaded.

c. The single tone modulated signal tests observe the RF spectrum output with test tone applied to the transmitter input. In the terminated mode, the transmitter input is terminated into its characteristic impedance while observing the RF spectrum for spurious emissions. The white noise loading tests consist of loading the transmitter input with white noise equal to the nominal input level of the transmitter and observing for spurious emissions. On twin sideband systems where multiplexers and demultiplexers are used to derive four independent VF channels, one white noise can be applied through the multiplexer to simultaneously load all four channels. Regardless of the method used, the spectrum analyzer will be used for all test sequences to measure the level of spurious emissions.

10-2. TEST EQUIPMENT.

a. RF spectrum analyzer with camera.

b. RF attenuators (variable).

c. White noise source (random noise generator).

d. Audio amplifier input termination.

e. Audio signal generator.

10-3. TEST PROCEDURES.

a. Single Tone Modulated Test.

(1) Establish the test setup as shown in figure 10-1. Allow approximately 50 minutes for the the equipment to warm up.

(2) This test can be performed while the system is in traffic and in its normal operating configuration. If performed in service insure that the audio input levels are adjusted to the level specified by the equipments' technical literature. An alternate method is to remove the system from an in-traffic condition and apply an audio signal to the transmitter input. Either procedure will produce the same results, however, the out-of-service condition may facilitate the analysis and detection of spurious emissions.

(3) Adjust the output of the signal generator for 700 Hz at the nominal 0 dbm0 reference level. This level may be obtained from the technical manuals or manufacturer's literature.

NOTE: Whenever possible, the attenuator should be connected to a low power sampling point. For example, the directional coupler in the external pickup arrangement should be used. The arrangement should be such that the signal power applied to the spectrum analyzer is sufficient to produce a convenient display with a dynamic range of at least 50 db without damaging the spectrum analyzer with excessive RF input.

(4) Adjust the spectrum analyzer to provide a logarithmic response and adjust the frequency dispersion to display a narrow bandwidth centered on the transmit frequency.

(5) Readjust the spectrum analyzer to display the frequencies over an increasing bandwidth. Photograph any irregular results observed on the spectrum analyzer.

NOTE: Pay particular attention to the harmonic frequencies of the intermediate frequency amplifier.

b. Baseband Terminated Method.

(1) Connect the equipment as shown in figure 10-1, with the input to the modulation amplifier terminated in its characteristics impedance.

(2) Complete the steps delineated in paragraphs 10-3a(1) through 10-3a(4). Pay particular attention to the note following paragraph 10-3a(3).

c. White Noise Loaded Method.

(1) Disconnect the normal transmitter input and connect the white noise generator as shown in figure 10-1. Disconnect the antenna and terminate the transmitter into a dummy load. Adjust the white noise generator output to the referenced level or 0 dbm0.

(2) Set the spectrum analyzer to a logarithmic response position and adjust the frequency dispersion so the 3 db RF carrier bandwidth is of sufficient width on the display to provide for photographing the RF bandwidth in kHz segments. Photographically, record the spectrum and mount the photographs on USACC Form 397-R (Test).

(3) Observe the spectrum frequencies over a range greater than ±5 times the bandwidth of the transmission system.

(4) Follow the steps delineated in paragraph 10-3a(1) and 10-3a(4) above.

(5) If four channel multiplexers are variable, connect the white noise loading to each of the individual channels while observing the spectrum with the analyzer. Photograph any unusual conditions and mount the photographs on USACC Form 397-R (Test).

d. Normalize the equipment and summarize the test data on USACC Form 351-R (Test).

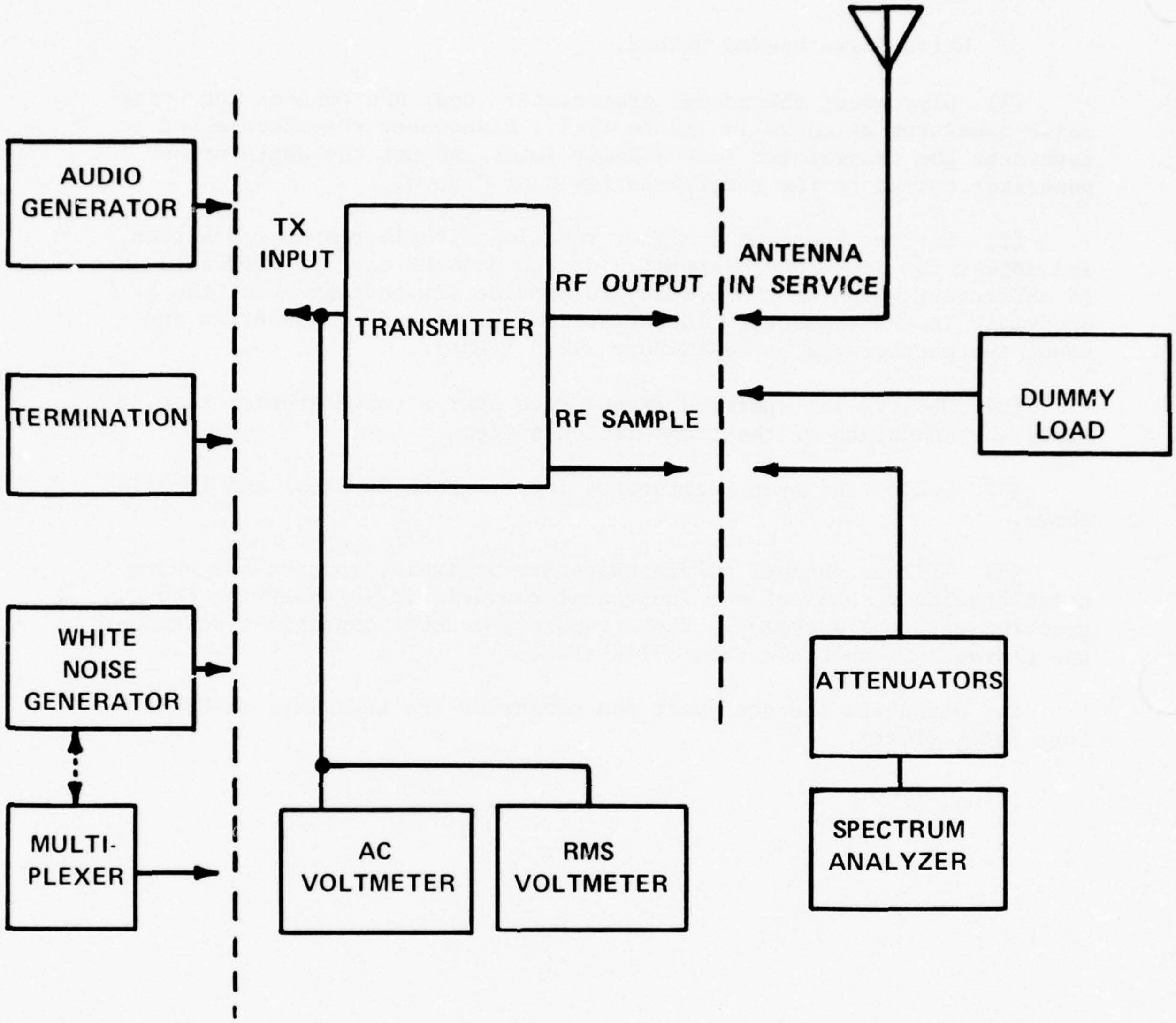


Figure 10-1. Transmitter spurious emissions, test setup.

CHAPTER 11

RTEP TEST 8, TRANSMITTER OUTPUT POWER AND VOLTAGE STANDING WAVE RATIO (VSWR)

11-1. PURPOSE.

a. The purpose of this test is to determine the RF output power level of an AM or FM radio system at its operating frequency. The voltage standing wave ratio (VSWR) at the transmitter output connection will also be measured during the test.

b. This is an in-service test with the transmitter connected to its normal antenna through a wavemeter that will read forward and reverse power. The RF output power does not exceed the design limits of the wattmeter.

11-2. DISCUSSION.

a. A perfect match between the antenna and the transmission line would present a VSWR of 1:1, but with an inherent impedance mismatch and line loss, some power is reflected back to the transmitter.

b. The VSWR may be calculated using the forward and reflected power readings. The reflected power may be determined by inserting a directional coupler between the transmitter and antenna and measuring with an RF wattmeter or power meter. In the case of the power meter, dbw may be converted to watts by:

$$P = \text{Antilog}_{10} \frac{A + R}{10}$$

where: P = power in watts

A = attenuation of coupler and all connecting lines

R = power meter reading in dbw

The following formula is then used to compute VSWR:

$$\text{VSWR} = \frac{1 + \sqrt{\dfrac{Pr}{Pf}}}{1 - \sqrt{\dfrac{Pr}{Pf}}}$$

where: VSWR = voltage standing wave ratio

P_f = forward power

P_r = reverse power

11-3. TEST EQUIPMENT.

a. Thru-line wattmeter with forward and reverse scales. (NOTE: The built-in coupler may be used if it has been calibrated recently.)

b. RF frequency counter.

c. Time domain reflectometer.

11-4. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 11-1 to measure the output of the transmitter into the antenna. The wattmeter should be as close as possible to the antenna. If a coupler is used, make connection between the coupler and the antenna, because the coupler contributes to power loss and may present some impedance mismatch to the line.

b. Where applicable, adjust the transmitter controls as follows:

(1) Modulation mode to normal.

(2) Position the TX/RX switch to TX.

(3) Tune the transmitter to the frequency being used for the test.

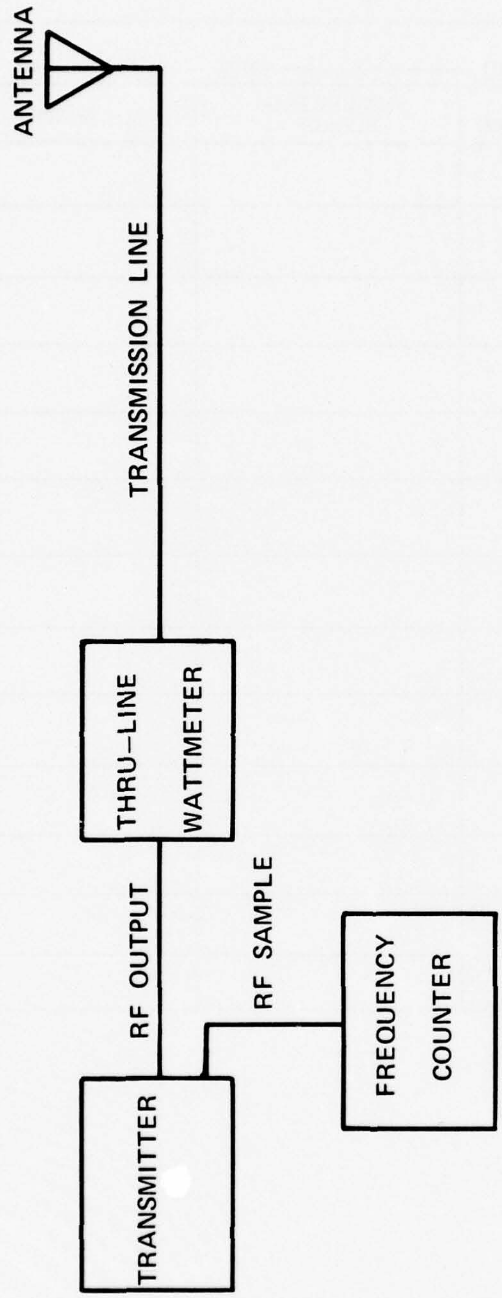
(4) Key the transmitter to CW.

c. Measure and record the forward and reverse power on USACC Form 401-R (Test), figure 11-2.

d. Repeat the above steps at each of the operating frequencies.

e. If unsatisfactory VSWR results are obtained during the test it may be necessary to use a time domain reflectometer to isolate discontinuities in the transmission line or antenna system.

f. Complete all test data elements and summarize the test results on USACC Form 351-R (Test).



NOTE: If coupler is used, make readings between the coupler and the antenna. In making the VSWR measurement, a directional coupler may be inserted in place of the thru-line wattmeter.

Figure 11-1. Transmitter output power and VSWR measurement, test setup.

TRANSMITTER OUTPUT POWER AND VSWR (CCR 702-1-3) DATA SHEET		PAGE NUMBER	NUMBER OF PAGES
		DATE (DAY, MONTH, YEAR)	
LOCATION	EQUIPMENT IDENTIFICATION	TEST ENGR SIGNATURE	

EQUIPMENT
MODEL NO ______________ SERIAL NO ______________ MFG ______________

FREQUENCY	MEASURED OUTPUT POWER (W)	REFLECTED POWER	VSWR

COMMENTS:

USACC Form 401-R (Test)
1 April 1977

Figure 11-2. Transmitter output power and VSWR, data sheet.

CHAPTER 12

RTEP TEST 9, ANTENNA VSWR AND TRANSMISSION LINE LOSS

(ALTERNATE PROCEDURE)

12-1. PURPOSE.

a. The purpose of this test is to determine the radio antenna's voltage standing wave ratio (VSWR) and the associated transmission line loss using return loss measurements.

b. This test is to be performed on both primary and backup transmit and receive antennas and transmission cables.

c. The results of this test should be compared to TM specifications and/or MIL-STD-188-317.

d. This test assumes the use of 50-ohm test equipment and 50-ohm antenna and transmission line equipment. It is important that the correct characteristic impedances for any particular test be determined so that appropriate steps can be taken to modify the test as appropriate.

12-2. TEST EQUIPMENT.

a. Spectrum analyzer.

b. Tracking generator.

c. Analyzer camera.

d. Directional coupler.

e. Coaxial attenuator (20 db)

f. 50-ohm noninductive terminating resistor (4 each).

g. 75-ohm noninductive terminating resistor (1 each).

12-3. TEST PROCEDURES.

a. Record the applicable data on top of USACC Form 351-R (Test).

b. Remove and lock out from service the antenna and associated transmission line to be tested. Disconnect the transmission line at the multicoupler or antenna matrix on the antenna side.

NOTE: When removing transmit antennas from service, the high voltage of the transmitter(s) must be shut off. Failure to do so may result in serious electrical shock and RF burns.

c. Establish the test setup shown in figure 12-1.

d. Adjust the frequency control of the RF output section of the spectrum analyzer for a center frequency of 5 MHz ±5 kHz. The scan width/division should be set at 1 MHz. This gives a total scan width to 10 MHz. The bandwidth and scan time must be adjusted to give maximum resolution.

e. Sweep the input to the antenna from 0 to 10 MHz with a 0 dbm signal from the tracking generator. Photograph the results, and record the following on each photograph:

(1) Location and date.

(2) Antenna type and number.

(3) Center frequency.

(4) Scan width.

(5) Bandwidth.

(6) VSWR calibrated lines.

(7) Y-axis scale.

f. Repeat steps 12-3 d and e using center frequencies of 15 MHz and 25 MHz. This will give a composite scan from 0 to 30 MHz.

g. Disconnect the antenna from the directional coupler. Terminate the load side of the directional coupler with a 2:1 mismatch (two 50-ohm terminations in series).

h. Sweep the input to load and note the level of the VSWR trace. Mark this level on the antenna VSWR photograph as the 2:2 calibration line on the data form.

i. Disconnect the 2:1 termination. Terminate the load side of the directional coupler with the 1.5:1 or 75-ohm termination and repeat steps 12-3h. Is is sometimes possible and preferable, depending on the test equipment used, to photograph the calibration lines directly in the photograph containing the antenna VSWR profile. On occasions it may be necessary to calibrate with a 3:1 mismatch, in which case, a 150-ohm termination must be used.

j. Remove all terminations from the directional coupler.

k. Connect the transmission line to the directional coupler.

l. Disconnect the transmission line at the base of the antenna. Insure that the open transmission line does not make undesired contact with other objects.

m. Adjust the spectrum analyzer for a center frequency of 5 MHz and sweep the input to the transmission line from 0 to 10 MHz with a 0 dbm signal from the tracking operator. Photograph the results, and record the information listed in paragraph 12-3e (1) through (7).

n. Repeat step m using center frequencies of 15 MHz and 25 MHz.

o. Return equipment to its normal configuration and complete the data sheet.

p. Each complete antenna or transmission line profile will consist of three photographs, 0-10 MHz, 10-20 MHz, and 20-30 MHz. These photographs must be trimmed and fitted together on USACC Form 397-R (Test) along with all appropriate information concerning test equipment settings and scales. Summarize the test results on USACC Form 351-R (Test).

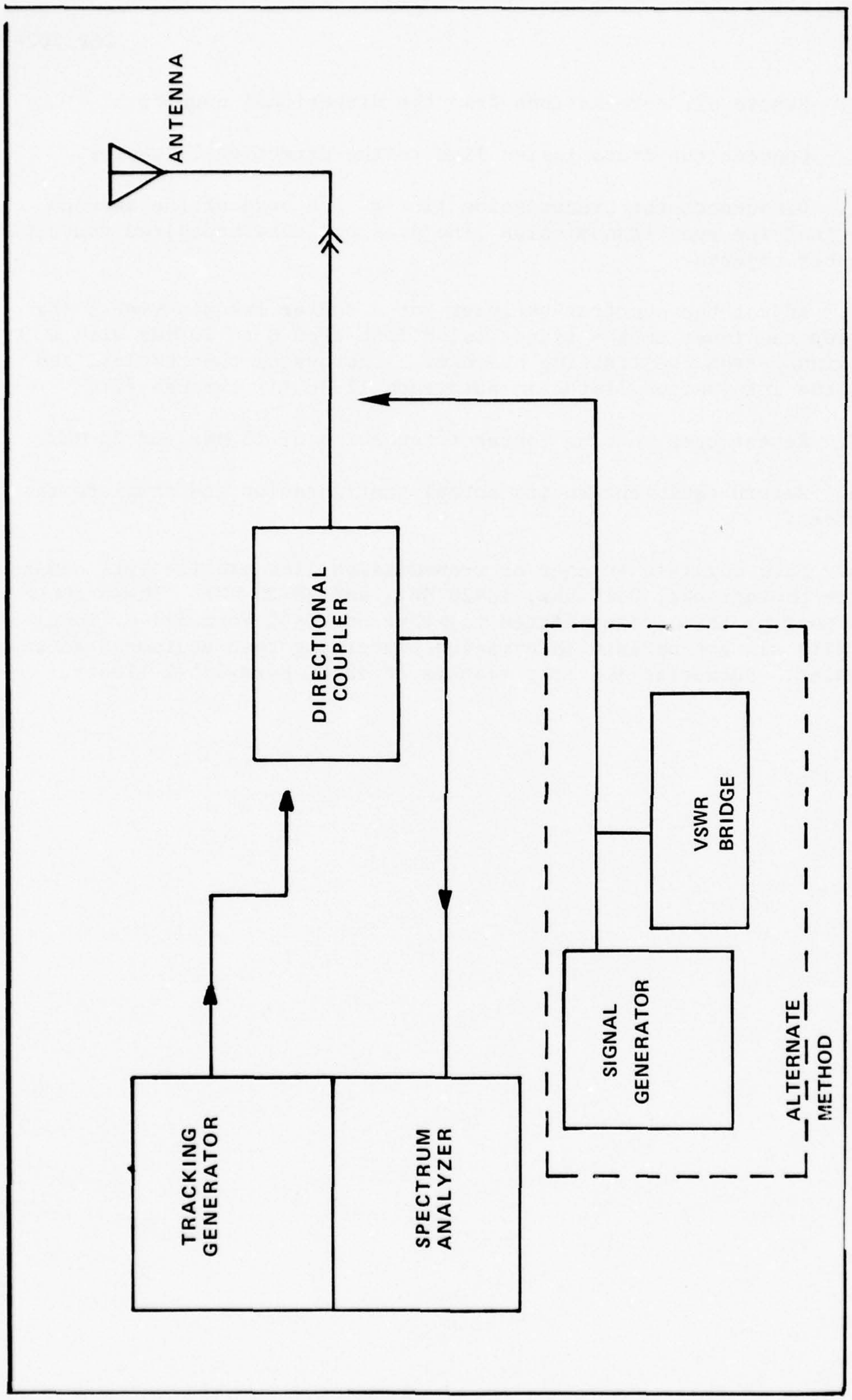


Figure 12-1. Antenna VSWR and transmission line loss, test setup.

CHAPTER 13

RTEP TEST 10, RADIO FM RECEIVER FREQUENCY RESPONSE

13-1. PURPOSE. The purpose of this test is to measure the audio frequency response and distortion of FM radio master station receivers.

13-2. TEST EQUIPMENT.

a. Audio signal generator.

b. RF signal generator.

c. AC voltmeter.

d. Attenuators (as required).

e. Distortion analyzer.

13-3. TEST PROCEDURES.

a. Establish the test setup shown in figure 13-1.

b. Using a 1 kHz test tone and frequency modulated RF signal generator, establish a convenient reference output level from the transceiver. Note the input level to the RF signal generator. This is the input reference level and is to be maintained for the remainder of this test.

c. Record the 1 kHz reference output level on USACC Form 399-R (Test), figure 7-2.

d. Adjust the audio signal generator for each frequency as listed on the data form and record the corresponding output level.

e. Complete the data form as shown by graphing the receiver response, normalized to the 1 kHz reference level.

f. Normalize the equipment and summarize the test results on USACC Form 351-R (Test).

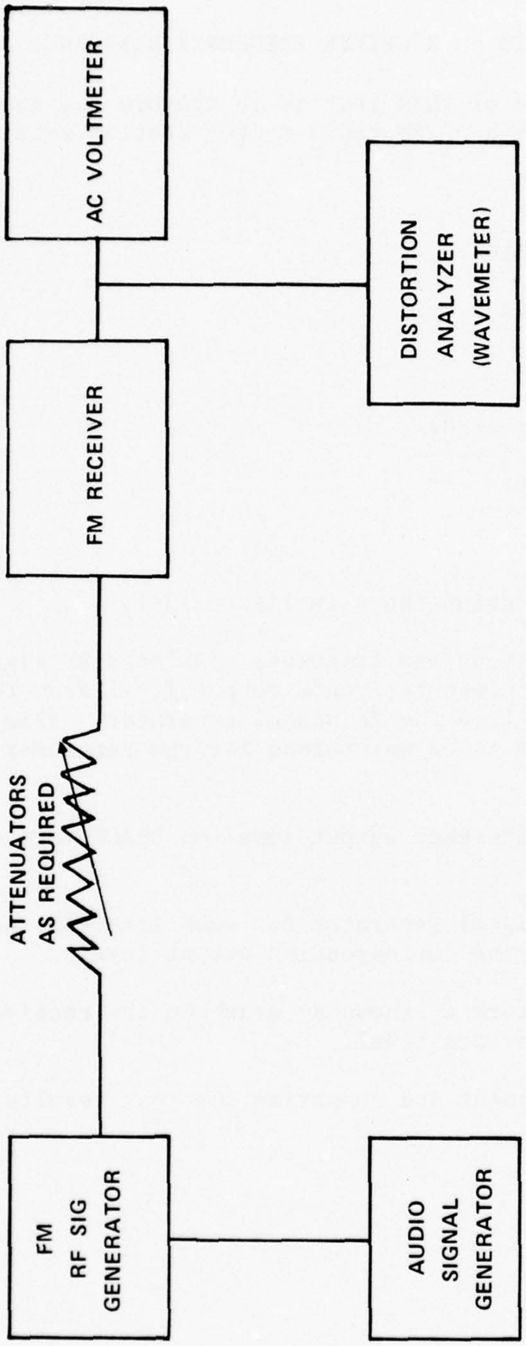


Figure 13-1. Radio frequency response, test setup.

CHAPTER 14

RTEP TEST 11, RECEIVER FM QUIETING, AGC, AND AUDIO OUTPUT CHARACTERISTICS

14-1. PURPOSE.

a. The purpose of this test is to measure the receiver quieting, AGC/IF voltage and audio output in relation to the receiver RF signal level (RSL). The RF input signal level is varied gradually in small increments while each parameter is measured and recorded.

b. FM quieting measures the effect on the receiver noise level with a change in the receive signal level and is a function of the RF amplifier AGC action. The resultant quieting curve from this test is used to determine the receiver's sensitivity and FM threshold.

c. Measurement of the AGC/IF amplifier voltage will establish a relationship between the AGC voltage of the receiver and the signal level received at the receiver input terminals. Where access can be obtained to the AGC voltage on receivers, an indication can be made of the relative signal strength received through the antenna system and applied to the receiver. Either AGC or IF signal power can be used to measure the RSL being applied to the receiver.

d. Receiver quieting measurements should be made using an ac VTVM at the audio output for all single channel FM systems.

14-2. TEST EQUIPMENT.

a. RF signal generator.

b. RF power meter.

c. RF frequency counter.

d. Frequency selective voltmeter.

e. Electronic voltmeter (VTVM).

14-3. TEST PROCEDURES.

a. Connect the test equipment as shown in figure 14-1.

b. Adjust the RF signal generator to the receive frequency.

c. Calibrate the RF signal generator output attenuator to correspond with the actual signal generator output level as it will appear at the receive RF (antenna) input. Calibration, therefore, should

include the RF interconnecting cables that are used to connect the RF signal generator to the receiver. Only cables that have been tested (or "calibrated") and are known to be good, should be used.

NOTE: When testing with RF signal generators, the output attenuators should never be adjusted for "zero" attenuation. It is advisable to have approximately 10 db of attenuation between the RF signal generator and its load. This will reduce any undesirable effects on the signal as the result of "loading" of the signal source or impedance mismatch.

d. Connect the RF signal generator output to the receiver RF (antenna) input. Insure that the receiver is isolated from the antenna.

e. Starting with a signal level of -120 dbm into the receiver, the quieting noise level and AGC voltage are measured for each RF signal generator level as shown on the data sheet. (USACC Form 402-R (Test), figure 14-2.)

f. Graph the measured data as instructed in 14-3e above. Determine the 20 db quieting point on the curve by drawing a line at the point where the noise power is reduced 20 db from its maximum value. Explain any unusual findings or significant deviations from the above procedures in the comments section of the data sheet.

g. Return the equipment to its normal operating condition and complete the data sheets.

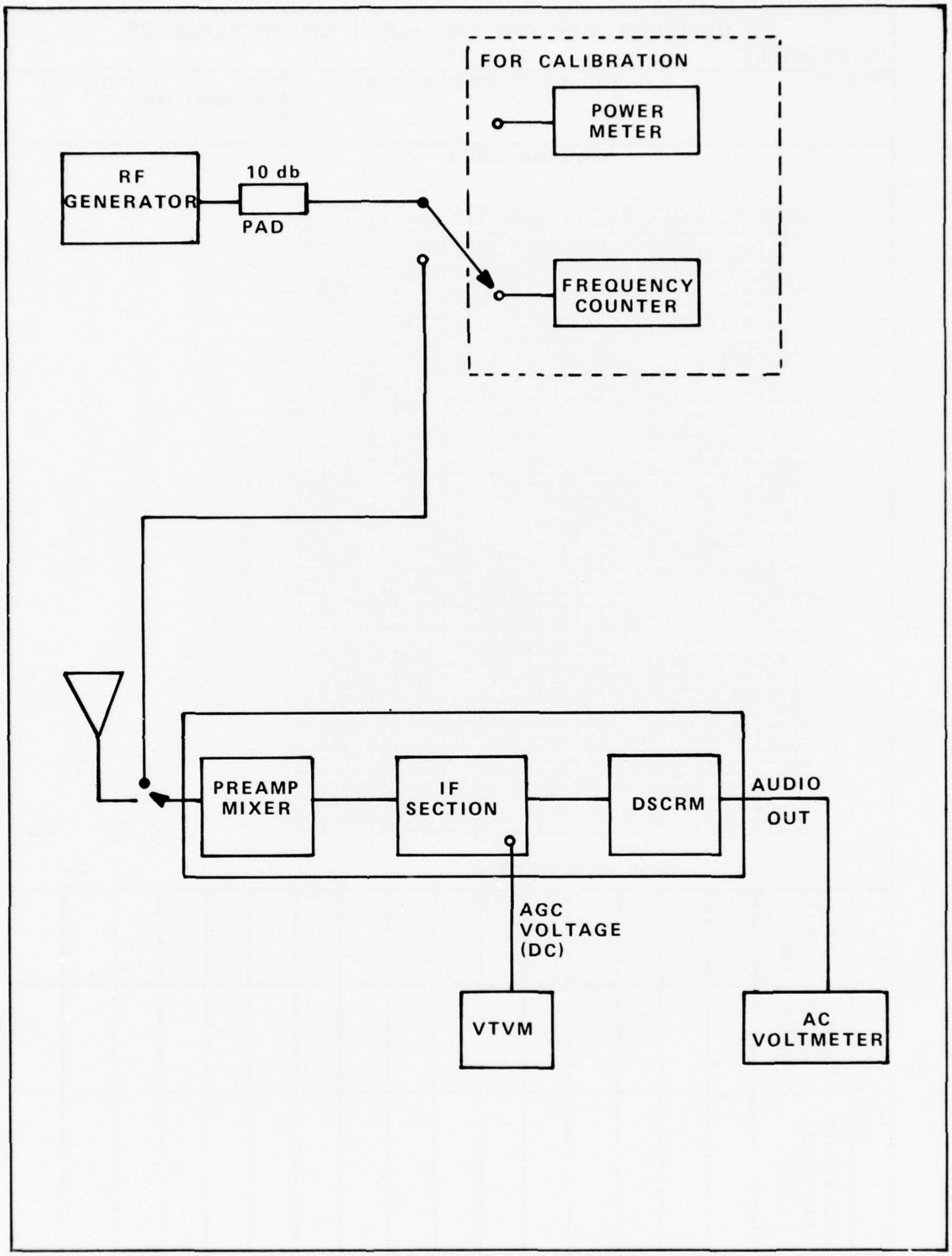
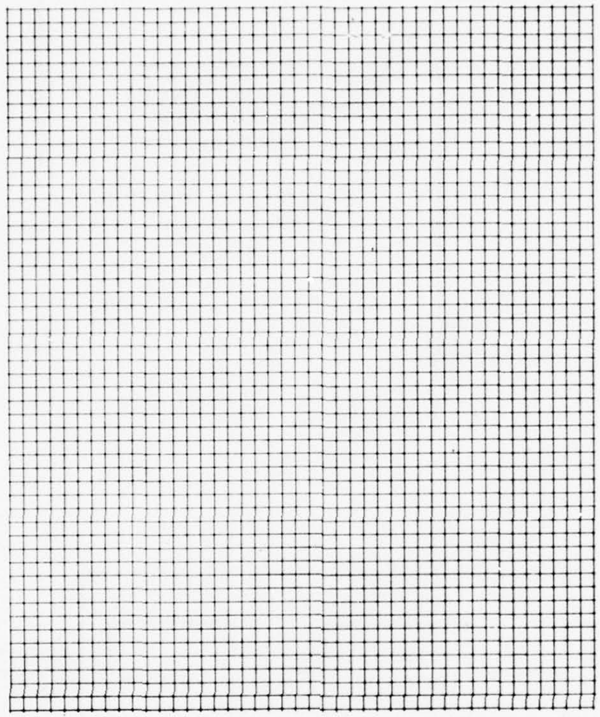


Figure 14-1. Receiver FM quieting, test setup.

FM RECEIVER QUIETING AND AGC/IF CHARACTERISTICS
DATA SHEET (CCR 702-1-3)

FACILITY	EQUIPMENT IDENTIFICATION	DATE (day, month, year)	TECH INIT

AGC/IF VOLTAGE



RF INPUT LEVEL

NOISE OUTPUT (dbm)

RAW DATA																
NOISE OUTPUT (dbm)																
AGC/IF VOLTAGE (VOLTS)																
RECEIVER RF INPUT LEVEL (dbm)																

USACC Form 402-R (Test)
1 April 1977

Figure 14-2. FM receiver quieting and AGC/IF characteristics, data sheet.

CHAPTER 15

RTEP TEST 12, RECEIVER SELECTIVITY/IF BANDPASS

15-1. PURPOSE.

a. The purpose of this test is to determine and plot the center frequency and selectivity of the receiver. It measures the IF bandpass characteristics at the 3 db, 6 db, and 30 db points. The total selectivity is determined largely by the IF portion of the receiver. The greater the number of stages and the lower the IF frequency, usually the better the selectivity.

b. The AGC voltage is monitored by a DC voltmeter (or oscilloscope). This AGC voltage is applied to the IF stages and the RF amplifier. Since the AGC voltage varies with detector input, the lesser signal will increase bias to the IF stages. Therefore, the signal to the detector will increase.

c. In this test we use an off-frequency adjustment to create a lesser signal. The increased bias voltage is monitored in order to determine the receivers bandpass or selectivity.

15-2. TEST EQUIPMENT.

a. RF signal generator.

b. Coaxial attenuators.

c. DC voltmeter.

d. RF frequency counter.

15-3. TEST PROCEDURES.

a. Connect the test setup as shown in figure 15-1. Connect the multimeter (or oscilloscope) to the AGC/AVC monitor point (dc level).

b. Establish a 1 kHz 30 percent modulation mode on the signal generator. This is the standard test signal.

c. With receiver properly tuned (the BFO tuned to the carrier), determine the AGC/AVC peak. (For some radios, the correct indication is a dip between two peaks.) This level is the reference level. This frequency as read on the counter should be on or very close to the desired channel frequency, and is entered on USACC Form 403-R (Test), figure 15-2.

d. Record the total attenuation inserted into the input of the receiver when the AGC is at its peak. Remove 3 db of attenuation from the variable attenuator(s). The AGC/AVC should increase accordingly. Adjust the frequency of the signal generator using the fine frequency control until the AGC/AVC monitor level returns to the reference level. Record the frequency at which this occurs on the data form. Now adjust the signal generator in the other direction using the fine frequency control until the reference level is accomplished again. Record this frequency reading on the data form. The bandwidth for the 3 db point can now be calculated as the difference of these two readings.

e. Repeat the procedures of paragraph 15-3d above for the 6 db and 30 db points. Other additional points may be measured if desired.

NOTE: For some receivers, the IF bandwidth is extremely narrow. Particular care will be required while adjusting the signal generator frequency to discern the AGC/AVC reference levels. Graph the total response on USACC Form 396-R (Test).

f. The average of the 3 db frequencies may be taken to determine how close the receiver actually is to the desired channel frequency. Critical adjustment of the signal generator fine frequency control while observing the AGC/AVC voltage for its absolute peak on the meter scale, or oscilloscope vertical presentation, will result in a very accurate receiver center frequency reading.

g. Summarize the test results and record all data on USACC Form 351-R (Test).

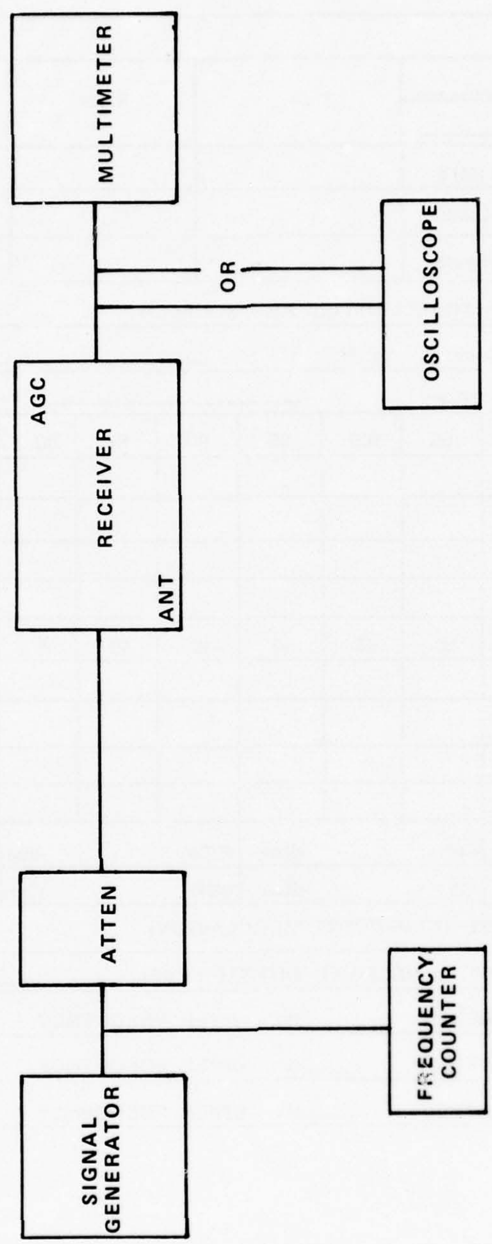


Figure 15-1. Receiver selectivity, test setup.

RECEIVER SELECTIVITY, SENSITIVITY, AND FREQUENCY RESPONSE DATA SHEET
(CCR 702-1-3)

FACILITY	EQUIPMENT IDENTIFICATION	DATE (day, month, year)	TECH INIT

1. RECEIVER SELECTIVITY

ASSIGNED FREQUENCY: ______ MEASURED FREQUENCY: ______		3 db	6 db	30 db
BANDWIDTH	UPPER BAND LIMIT			
	LOWER BAND LIMIT			
	TOTAL BANDWIDTH			

2. RECEIVER SENSITIVITY, AGC CHARACTERISTICS, AND SQUELCH

RF LEVEL REQUIRED FOR 10 db (S + N)/N: ______

AGC VOLTAGE AT 10 db (S + N)/N: ______

RF LEVEL (-dbm)	110	105	100	95	90	85	80	75	70
AGC (VOLTS)									
(S + N) (dbm)									
N (dbm)									
(S + N)/N (db)									
RF LEVEL (-dbm)	65	60	55	50	45	40	35	30	25
AGC VOLTS									
(S + N) (dbm)									
N (dbm)									
(S + N)/N (db)									

SQUELCH LEVEL				
	CAPTURE	CW -dbm	CCW -dbm	NORM -dbm
	RELEASE	CW -dbm	CCW -dbm	NORM -dbm

3. RECEIVER FREQUENCY RESPONSE (30 PERCENT MODULATION)

30 PERCENT MODULATION 1000 Hz RECEIVER OUTPUT LEVEL ______ dbm

3 db RESPONSE LOWER FREQUENCY: ____Hz UPPER FREQUENCY ____Hz

6 db RESPONSE LOWER FREQUENCY: ____Hz UPPER FREQUENCY ____Hz

10 db RESPONSE LOWER FREQUENCY: ____Hz UPPER FREQUENCY ____Hz

4. COMMENTS:

USACC Form 403-R (Test)
1 April 1977

Figure 15-2. Receiver selectivity, sensitivity, and frequency response, data sheet.

CHAPTER 16

RTEP TEST 13, RECEIVER SPURIOUS RESPONSE

16-1. PURPOSE. The purpose of this test is to check the ability of the receiver to reject off-frequency signals. Of prime importance is the image frequency. The test can also be used to check suspected interfering frequencies such as adjacent transmitter frequencies.

16-2. TEST EQUIPMENT.

a. RF signal generator.

b. RMS voltmeter.

c. Multifunction voltmeter.*

d. Isolation transformer.

e. Frequency counter.*

f. Oscilloscope.*

g. Spectrum analyzer.*

h. RF voltmeter.*

* Optional for monitoring purposes.

16-3. TEST PROCEDURES.

a. Use the test setup shown in figure 16-1. This test can be made as thorough as desired if the generator is easily tuned and has a stable level.

b. Tune the receiver to the frequency under test. Establish a 10 db $\frac{S + N}{N}$ ratio and record the RF level necessary for this on the test cover page, USACC Form 351-R (Test).

c. Off-tune and increase the signal generator output at least 80 db. Modulate the carrier 30 percent with a 1 kHz tone for monitoring purposes.

d. Tune the signal generator across the applicable band and look for a reaction in the receiver by monitoring:

(1) The audio with an oscilloscope, a fast-reading VTVM or a speaker.

(2) The AGC, if externally available, with an oscilloscope or a fast reacting multimeter.

(3) The IF, if externally available, with a spectrum analyzer, oscilloscope or RF voltmeter.

e. When a suspected interfering signal is discovered, attempt to establish a 10 db $\frac{S+N}{N}$ audio output using the signal generator level control. Then record this interfering signal frequency as "f_i" and the level as "f_1" level. The level ratio between "f_o" and "f_1" (in db) is the spurious rejection of the device.

f. There will be more than one "f_o" only if there is more than one operational frequency for the device.

g. If there are suspected interfering frequencies "f_i," they should be investigated. The image frequency should be specifically investigated. The image frequency is found by:

(1) Subtracting twice the IF from the operational frequency if the operational frequency is greater than the local oscillator (LO) frequency.

(2) Adding twice the IF to the operating frequency if the operating frequency is less than the LO frequency.

h. Record any spurious frequency responses found and the level detected on a USACC Form 351-R (Test), together with any comments on the origin or cause of the interference.

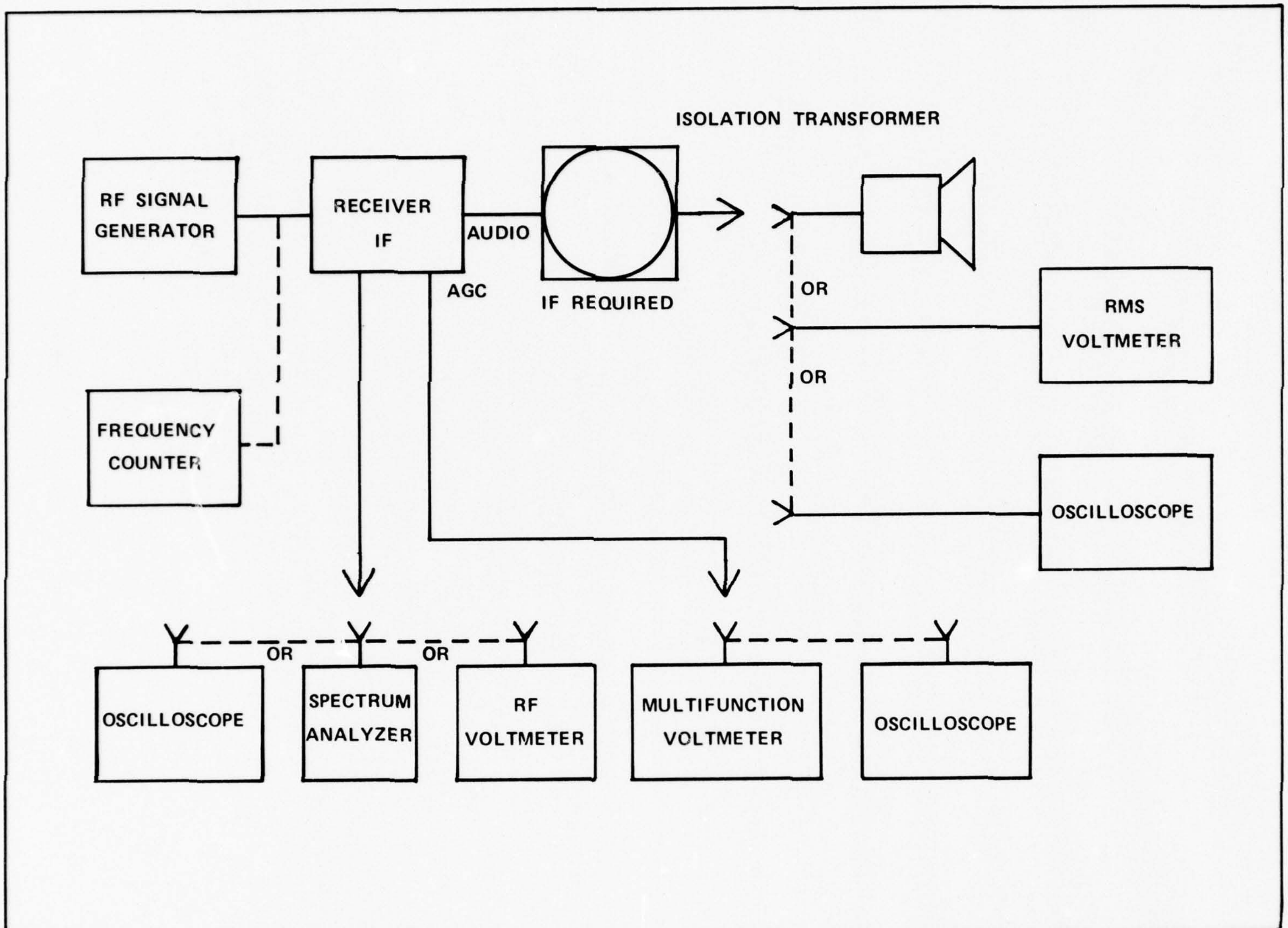


Figure 16-1. Receiver spurious response, test setup.

CHAPTER 17

RTEP TEST 14, RECEIVER SENSITIVITY, AGC, AUDIO, AND SQUELCH (AM RADIO)

17-1. PURPOSE. The purpose of this test is to analyze the sensitivity, audio parameters, and AGC action of an HF receiver. Measuring the audio and AGC response versus the RF level and frequency response provides the audio and sensitivity characteristics of a receiver. The squelch function of the receiver is a related action and is included as part of the receiver evaluation.

17-2. TEST EQUIPMENT.

a. RF signal generator.

b. RMS voltmeter.

c. Multifunction voltmeter.

d. Distortion analyzer.

e. Isolation transformer.

f. Line bridging transformer.

g. Frequency counter.

17-3. TEST PROCEDURES.

a. Receiver Sensitivity. The sensitivity of a receiver is determined by the components in the front end, such as the number of RF amplifier and its ability to capture and amplify incoming RF signals. The better the signal to noise (S/N) ratio at a very low input level, the better the receiver's ability to distinguish between signal and noise at that level. A very good S/N ratio is hard to attain with an AM receiver because the bandwidth must include both sidebands. Increasing the bandwidth will essentially decrease the sensitivity.

(1) Interconnect the equipment as shown in figure 17-1.

(2) Where applicable, adjust the receiver controls as follows:

(a) Position the RF gain at maximum (clockwise).

(b) Position the AF gain at maximum (clockwise).

(c) Position the audio quieting at maximum (counterclockwise).

(d) Position the squelch switch to OFF.

(e) Switch on the AVC.

(f) Position the frequency response switch to narrow.

(g) Position the TX/RX switch to RX.

(h) Position the noise limited switch to ON.

(i) Adjust the switch on the audio output meter to read on the highest decibel (mW) scale.

NOTE: The output meter can be damaged by sudden changes in the output level of the receiver; therefore the highest scale setting is recommended during initial turn-on of the equipment or during any adjustment of receiver.

(3) Turn the receiver, signal generator, and frequency counter on and allow a 30-minute warmup.

(4) Set the signal generator modulation frequency switch as follows:

(a) 1000 Hz for UHF receivers.

(b) 400 Hz for VHF receivers.

(5) Adjust generator for 30 percent modulation.

(6) Set the attenuator on the signal generator to minimum output.

(7) Adjust the signal generator to the assigned local frequency of the receiver under test.

(8) Increase the signal generator output until the receiver output exceeds the receiver output noise level by at least 50 mW.

(9) Reduce the AF gain on the receiver until 50 mW of output is indicated.

(10) Adjust the antenna trimmer capacitor on the receiver to achieve the maximum receiver output.

(11) Adjust the signal generator to obtain standard test voltage input to the receiver under test as follows:

(a) 5 microvolts for VHF receivers.

(b) 6 microvolts for UHF receivers.

(12) Reduce the AF gain control to achieve the power output specified in the equipment instruction book of the receiver.

(13) Remove the modulation from the signal generator.

(14) Vary the signal generator output until a power ratio of 10 db (10:1) is obtained when the modulation is turned on and off.

(15) Record the standard voltage level required to obtain this 10 db value. The sensitivity of the receiver is the standard test voltage. level required to obtain a signal-plus-noise (modulation) to noise-alone (modulation off) ratio of 10:1. Record all measured values.

(16) Repeat the test procedure for each assigned frequency of the receiver, or at least one frequency for each band or tuneable receivers.

(17) Enter the data taken during this procedure on USACC Form 405-R (Test), figure 17-2.

b. Audio Output, AGC, and Squelch.

(1) Interconnect the equipment as shown in figure 17-1.

(2) Where applicable, adjust the receiver controls as follows:

(a) Position the RF gain at maximum.

(b) Position the AF gain at maximum.

(c) Position audio-quieting at maximum.

(d) Position the squelch switch to OFF.

(e) Switch on the AVC.

(f) Position the TX/RX switch RX.

(g) Position the noise limiter switch to ON.

(h) Adjust the switch on the audio output meter to read on the highest mW scale.

NOTE: The output meter can be damaged by sudden changes in the output level of the receiver; therefore, the highest scale setting is recommended during initial turn-on of equipment or during any adjustment of receiver.

(3) Turn the receiver, signal generator, counter, output meter, and voltmeter on and allow them to warmup for 30 minutes.

(4) Adjust the signal generator for 30 percent modulation.

(5) Set the signal generator modulation frequency control as follows:

(a) 1000 Hz for UHF receivers.

(b) 400 Hz for VHF receivers.

(6) Set the attenuator to minimum output.

(7) Adjust the signal generator to the assigned frequency of the receiver under test.

(8) Increase the signal generator output gradually until maximum power is obtained from the receiver. Record the AGC voltage obtained at each level of generator output.

(9) Note and record the maximum value of audio power output on the meter.

(10) Repeat the above steps for all assigned frequencies on fixed frequency receivers. The procedure should be repeated for at least one frequency in each band for tuneable receivers.

(11) On receivers with squelch capability, record the level at which the squelch activates while changing the generator RF levels as in para 3, above.

c. Frequency Response and Distortion. Return the RF signal to standard test mode (30 percent at 1 kHz) and the receiver to normal operational audio level setting. Note the modulation frequency and level (in dbm). Next, retune the audio frequency downward until the signal falls 3, 6, and 10 db (from 1 kHz level) and record all readings. Tune the audio generator upward and repeat the readings at the 3, 6, and 10 db levels. Other levels may be measured as necessary. These data may be graphed on USACC Form 405-R (Test), figure 17-2. Summarize the test results on the test cover page, USACC Form 351-R (Test).

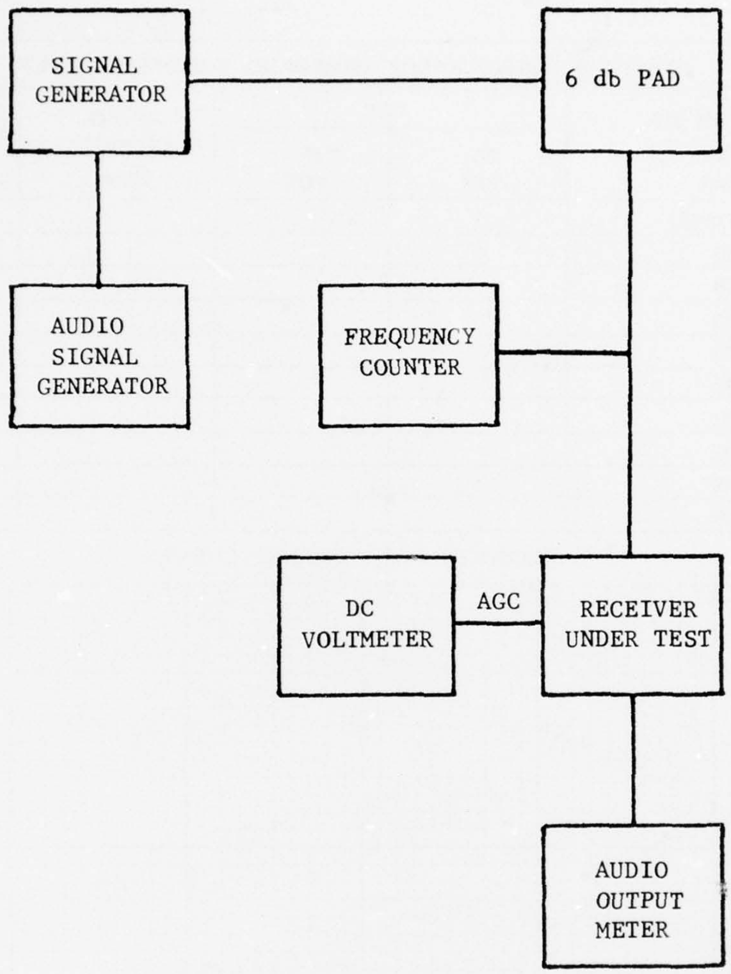


Figure 17-1. Receiver sensitivity, test setup.

RECEIVER MEASUREMENTS

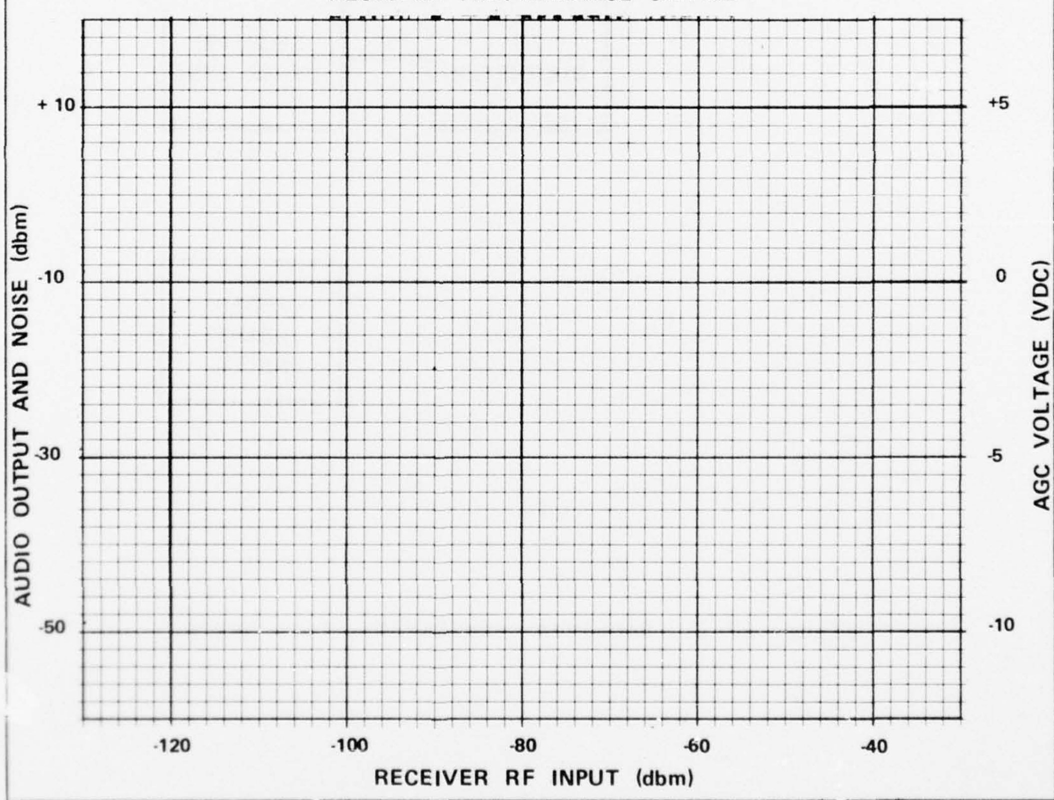
DATA SHEET

FACILITY	EQUIPMENT IDENTIFICATION	DATE	BY

RECEIVER PERFORMANCE (SIDEBAND EQUIPMENT ONLY)

RECEIVER RF INPUT (dbm)	AGC		AUDIO OUTPUT (dbm)	DISTORTION (db)
	RF VDC	IF VDC		
NO INPUT				
120				
110				
100				
90				
80				
70				
60				
50				
40				

RECEIVER PERFORMANCE CURVES



USACC Form 405-R (Test)
1 April 1977

Figure 17-2. Receiver measurements, data sheet.

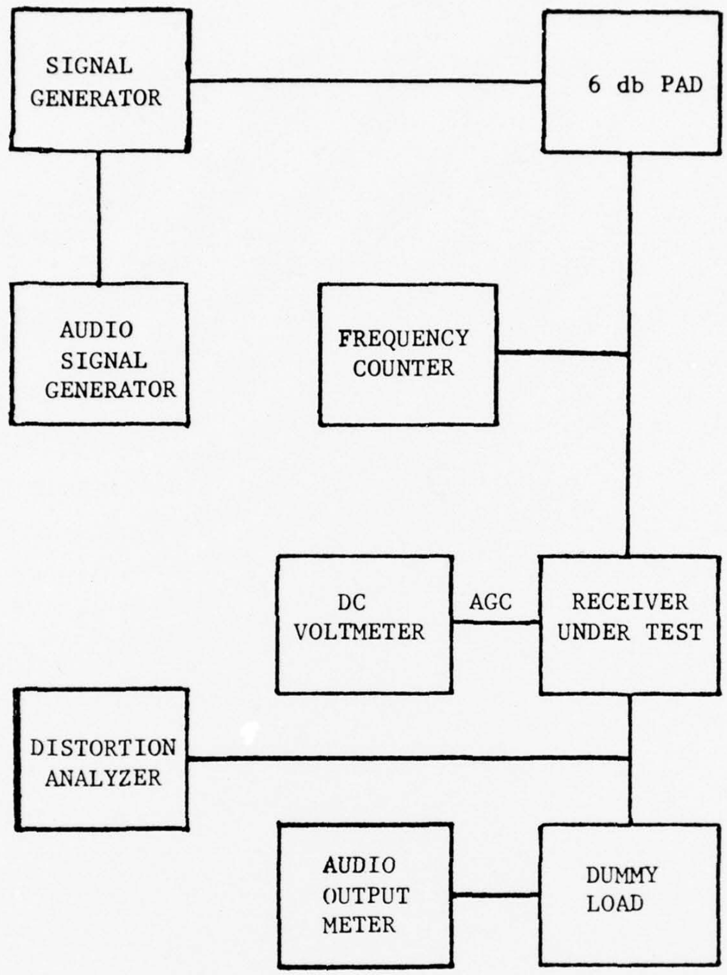


Figure 17-3. Audio output and AGC, test setup.

CHAPTER 18

RTEP TEST 15, RADIO SERVICE AREA RF FIELD STRENGTH

18-1. PURPOSE.

a. The purpose of this test is to evaluate the service area coverage of the FM base station's transmitter.

b. The following test procedures are, of necessity, general in nature. More specific test procedures should be developed based on the type of TMDE available and the degree of thoroughness desired.

18-2. TEST EQUIPMENT.

a. RF field strength meter with monitoring equipment.

b. Mobile radio (for coordination).

18-3. TEST PROCEDURES.

a. After making a determination of the required service area (camp, post, city limits) obtain copies of the topographic maps of the area in sufficient scale to show major features which may affect the radiated RF signal.

b. On the maps, plot either a radial and concentric circle pattern centered on the base station transmitter or a cross-hatched pattern throughout the service area. Intersections should be of sufficient number and dispersed throughout the service area to allow for the degree of analysis desired. Label each of these intersections for ease in identification and tabulation. In lieu of specific labels, the map grid coordinates may be used.

c. At, or as close as is practical to each of the geographical locations represented by the intersections determined in 18-3b above, measure the carrier field strength. Also record the level of any interfering signals which may be found.

d. Analysis of the above data will reveal whether there are any "shadowed" areas or areas with signal levels below the usable level for the equipment in use.

e. Additional measurements should be made in shadowed or marginal areas to determine the seriousness of the problem.

CHAPTER 19

RTEP TEST 16, STATION GROUND MEASUREMENT

19-1. PURPOSE. The purpose of this test is to determine by means of a null balance earth tester the resistance of the ground distribution system throughout the cable plant. An adequate station ground and ground distribution system provides a common electrical reference point for all equipment in an area and eliminates any difference of potential between pieces of equipment and between equipment and earth. The acceptable standard for this test is 5 ohms or less. The test method is the fall-of-potential earth resistance test.

19-2. TEST EQUIPMENT.

a. Null balance earth tester with accessory kit.

b. Sledge hammer (for driving ground rods).

19-3. TEST PROCEDURES.

a. With the aid of site drawings, locate the connection of the station ground to the earth electrode.

b. Connect the test instrument as shown in figure 19-1. The null balance earth tester should be located as close to the earth electrode as possible. Terminals P1 and C1 on the test instrument are connected to the earth electrode under test. (This configuration removes the resistance of the test lead from the measured value.) The first reference rod "C2" should be placed as far from the earth electrode as practical; this distance will probably be limited by the geography of the surroundings. The distance should be a minimum of 100 feet from the earth electrode. Following is a useful guide to P2 and C2 placement when a grid ground is to be tested.

DIAGONAL DIMENSION	DISTANCE E-P2	DISTANCE E-C2
4	62	100
6	78	125
8	87	140
10	99	100
12	105	170
14	118	120
16	124	200
18	130	210
20	136	220
40	198	320
60	242	390
80	279	450

DIAGONAL DIMENSION	DISTANCE E-P2	DISTANCE E-C2
100	310	500
120	341	550
140	366	590
160	397	640
180	422	680
200	440	710

The potential-reference rod "P2" is driven in at a point on a straight line between the earth electrode and "C2" and at a distance from the earth electrode that is 62 percent of the distance from the earth electrode to reference rod "C2." The leads should be connected to the rods and instrument. The instrument controls are shown in figure 19-2.

c. Set the range switch on the instrument to x0.01 and the digital readout of the balancing resistor dials to 999. Turn the generator crank slowly and note the galvanometer deflection. If the deflection is positive (+), increase range factor to x0.1 or higher until the deflection becomes negative (-). When the deflection is (-) decrease value of the balancing resistor, digit by digit, starting with the left knob, then the center and finally the right knob, until the galvanometer is nulled. The generator must be cranked while all adjustments on the balancing resistor are made. The cranking speed of the generator should be a minimum of 160 revolutions per minute (rpm) for maximum sensitivity. To avoid the effects of stray currents in the soil, it may be necessary to increase the cranking speed to 200 rpm or more.

Resistance under test = dial reading x range factor

19-4. DATA RECORDING.

a. Complete the top of data sheet, USACC Form 351-R (Test).

b. Make comments as necessary on the data sheet including historic data where available (stating resistance, date, and source of information); and a listing of applicable drawings.

c. Complete the data requirements of the data sheet USACC Form 300-R (Test), figure 19-3, as follows:

BLOCK	ENTRIES
1.0	STATION GROUND
1.1	Enter the measured resistance of the earth electrode.
1.2	Enter the distance E-C2; indicate feet or meters.
1.3	Enter the distance E-P2; indicate feet or meters.

BLOCK	ENTRIES
1.4	Describe the station ground commenting on the soil type, soil condition, condition of the earth electrode assembly, marking, type of connections, station ground distribution box, provision for watering, etc.
1.5	Enter the size of the station ground conductor (i.e., - 1000 MCM, 4/0 AWG, 2 AWG, 3" x¼" Cu Bar, 2" x 10 GA Cu Strap, braid).
1.6	Enter the type of chemical treatment used (i.e., none, magnesium sulphate, copper sulphate, sodium nitrate, calcium chloride, sodium chloride, iron sulphate, potassium nitrate, ammonium nitrate, activated charcoal, coke).
2.0	INTERIOR GROUND DISTRIBUTION
2.1	Describe the interior ground distribution commenting on condition, marking, insulation, connectors, and branching.
2.2	Enter the size of the interior ground feeder (i.e., - 750 MCM, 4/0 AWG, 2 AWG).
2.3	Enter the size of the rack ground feeder (i.e., - 2 AWG, 6 AWG).
3.0	EXTERIOR GROUND DISTRIBUTION
3.1	Describe the exterior ground distribution commenting on condition, marking, method of connection and bonding, and list of major items connected.
3.2	Enter the size of the exterior ground feeder (i.e., - 500 MCM, 2/0 AWG, 2 AWG).
3.3	Enter the size of the exterior ground distribution conductor (i.e., 2/0 AWG, 2 AWG).

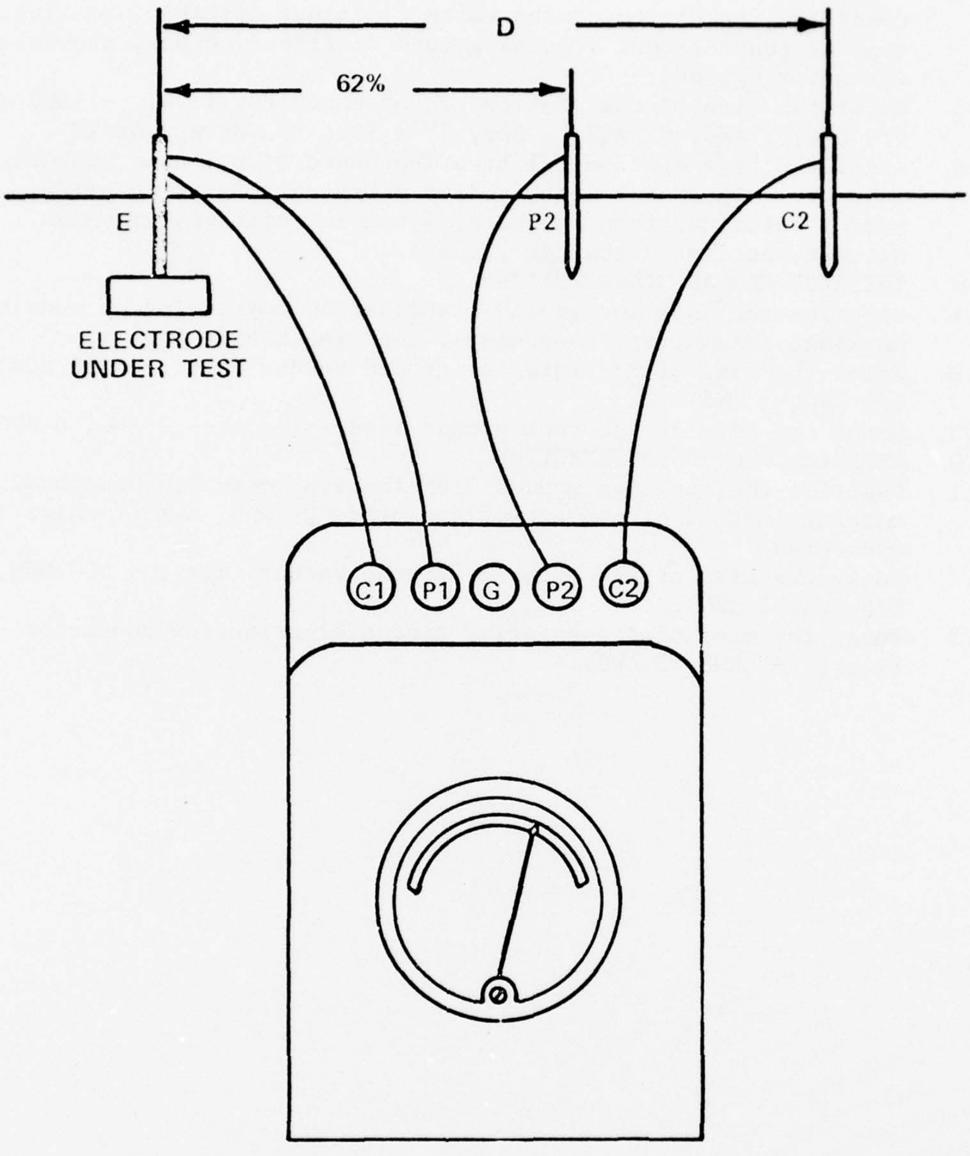


Figure 19-1. Station ground, test setup.

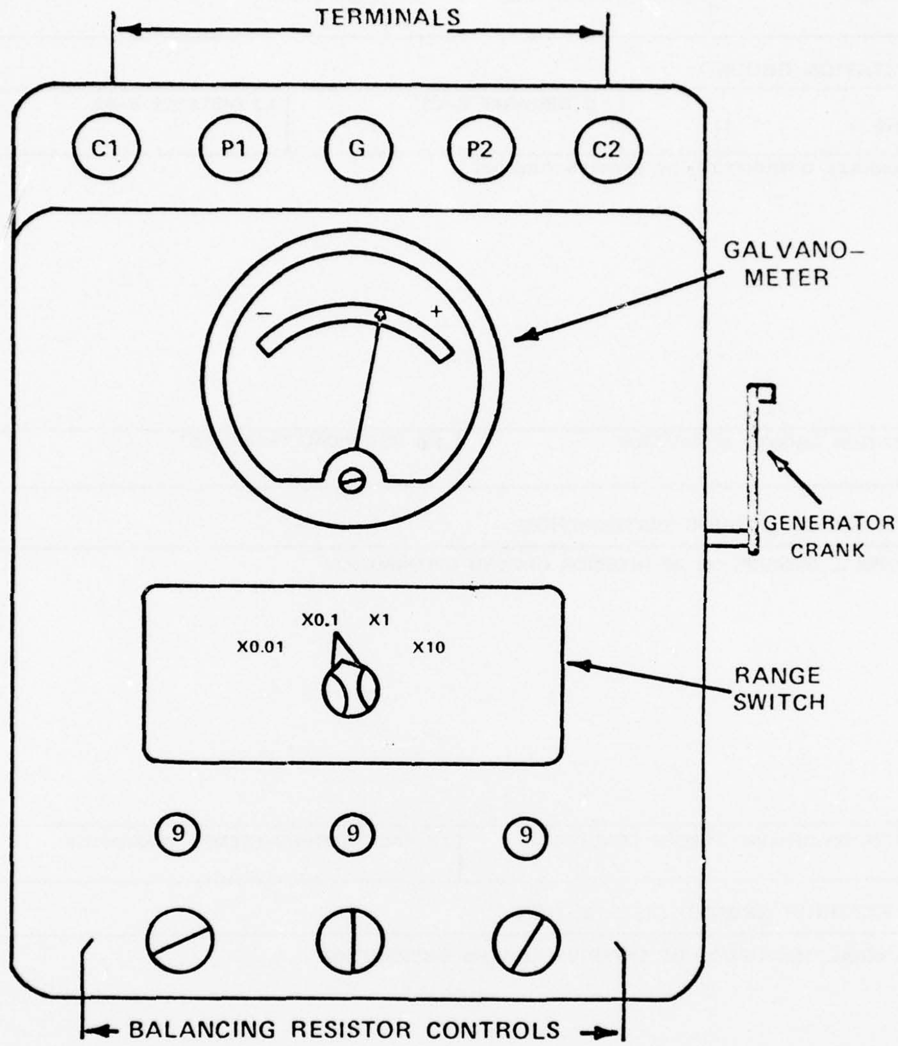


Figure 19-2. Equipment controls, station ground.

STATION GROUND DATA SHEET		PAGE OF PAGES TEST DATE
DCS LINK	STATION UNDER TEST	TEST ENGR.

1.0 STATION GROUND

1.1 RE = Ω	1.2 DISTANCE E–C2	1.3 DISTANCE E–P2

1.4 GENERAL DESCRIPTION OF STATION GROUND

1.5 STATION GROUND CONDUCTOR	1.6 CHEMICAL TREATMENT

2.0 INTERIOR GROUND DISTRIBUTION

2.1 GENERAL DESCRIPTION OF INTERIOR GROUND DISTRIBUTION

2.2 INTERIOR GROUND FEEDER CONDUCTOR	2.3 RACK GROUND FEEDER CONDUCTOR

3.0 EXTERIOR GROUND DISTRIBUTION

3.1 GENERAL DESCRIPTION OF EXTERIOR GROUND DISTRIBUTION

3.2 EXTERIOR GROUND FEEDER CONDUCTOR	3.3 EXTERIOR GROUND DISTRIBUTION CONDUCTOR

USACC FORM 300-R (TEST)
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Figure 19-3. Station ground, data sheet.

APPENDIX A

TEST, MAINTENANCE, AND DIAGNOSTIC EQUIPMENT (TMDE)
FOR
RADIO SYSTEMS TEST TEAMS

Electronic Test Equipment	Military (JETDS) Nomenclature	PIL LIN Equivalent	Quantity
Modulation Indicating Meter[1]	Lamkin 107		1
Frequency Measuring Device and Detection[1]	Lamkin 205D		1
Digital Multimeter	HP 3470		
Digital Display	HP 34750	60064N	1
Plug-in Multimeter	HP 34702A	60063N	1
Plug-in Battery Module[1]	HP 34720A		1
VSWR Meter	HP 415E E07, AN/USM-261	M38866	1
Signal Generator	HP 606AC15, AN/GRM-50	60150N	1
Signal Generator	HP 608E E02, AN/USM-44B	60156N	1
Signal Generator	HP 8614A, AN/USM-213	J53974	1
Transmission Test Set	HP 3550B H03, AN/USM-423	60191N	2
Frequency Counter	HP 5300A, TD-1209/U	09525N	1
Module	HP 5302A, TD-1211/U	60066N	1
Module[1]	HP 5303B		1
Module[1]	HP 5310A		1
Oscilloscope	TEK 475, OS-261P/U	N33151	1
Distortion Analyzer	HP 334A C10, AN/URM-184A	G26515	1
White Noise Source	OA-2090A, AN/GSM-161A	V81982	1
Spectrum Analyzer	HP 8552B, PL-1388/U	60185N	1
RF Section	HP 8553B, PL-1399/U	60186N	1
Tracking Generator	HP 8443A, SG-1122/U	60184N	1
RF Field Strength Meter	NM-17/27	60193N	1
Frequency Selective Voltmeter	HP 312B, TS-3066(V)3/U	60176N	1
RF Power Meter[1]	HP 436A		1
Camera Oscilloscope[1]	TEK C-30A-PE w/adapter		1
Test Set Radio Frequency Power	AN/URM-120	V89534	1
Earth Tester	TS-3221/U	V82084	1

[1]Non-PIL Equipment

EQUIPMENT	RTEP 1	RTEP 2	RTEP 3	RTEP 4	RTEP 5	RTEP 6	RTEP 7	RTEP 8	RTEP 9	RTEP 10	RTEP 11	RTEP 12	RTEP 13	RTEP 14	RTEP 15	RTEP 16				
Modulation Indicating Meter			X	X																
Frequency Measuring Device & Detection						X		X												
Digital Multimeter	X	X			X						X	X	X	X						
VSWR Meter																				
Signal Generator, HP 606AC15						X				X	X	X	X	X						
Signal Generator, HP 608E E02						X				X	X	X	X	X						
Signal Generator, HP 8614A						X				X	X	X	X	X						
Transmission Test Set	X	X	X	X			X			X	X		X	X						
Frequency Counter	X		X	X	X	X		X			X	X	X	X						
Oscilloscope			X									X	X							
Distortion Analyzer			X							X				X						
White Noise Source							X													
Spectrum Analyzer		X	X	X	X		X		X				X							
Tracking Generator									X											
RF Field Strength Meter															X					
Frequency Selective Voltmeter											X									
RF Power Meter											X									
Camera Oscilloscope		X	X				X		X											
Test Set Radio Frequency Power	X	X	X			X		X												
Earth Tester																X				

APPENDIX B

RADIO SYSTEMS TECHNICAL EVALUATION TEAM SAMPLE TEST REPORT

TECHNICAL EVALUATION TEAM REPORT

RCS:

FOR

____

STATION/FACILITY

____

O&M AGENCY

PREPARED BY

____

(AGENCY PREPARING REPORT)

____

(DATE OF REPORT)

Sample RTEP report.

TABLE OF CONTENTS

VOLUME I. EVALUATION SUMMARY

(Volume II will contain the raw data sheets. A table of contents should be prepared for this volume.)

Sample RTEP report. (continued)

AD-A039 487 ARMY COMMUNICATIONS COMMAND FORT HUACHUCA ARIZ F/G 17/2.1

PRODUCT ASSURANCE, OPERATIONAL QUALITY ASSURANCE, RADIO SYSTEMS--ETC(U)

MAR 77

UNCLASSIFIED ACC-CCP-702-8 NL

2 OF 2

AD A039487

END

DATE FILMED 6-77

RADIO SYSTEMS TECHNICAL EVALUATION TEAM SAMPLE TEST REPORT

1.0 GENERAL. The performance of the radio systems at site Y were evaluated in accordance with CCP 702-2. Results of the evaluation are summarized in paragraph 2.0 and the key test elements are tabulated in paragraph 6.0. (The raw test data worksheets are not included in this sample report in the interest of economy, however, these data would be provided as Volume II of the actual report.)

1.1 PERIOD OF EVALUATION. Enter the start through ending dates of the evaluation in this subparagraph.

1.2 O&M AGENCY. Enter the complete organizational designation including the mailing address of the activity having operation and maintenance responsibility.

1.3 TEAM COMPOSITION.

Name	Rank/Rating	Title
James R. Garner	WO	Team chief
Dave E. Perfor	E-7	Field radio repairman
Kris A. Dorman	E-6	Antenna repairman

(List all team members.)

1.4 KEY PERSONNEL CONTACTED.

Name	Rank/Rating	Organization/Office
B.E. Whittle	MAJ	USACC/C-E officer
R.T. Jopler	CPT	USACC/Executive officer
A.C. Porlan	CIV	USACC/Maintenance officer

(Include all key personnel contacted by the test team.)

2.0 SUMMARY OF TEST RESULTS.

2.1 SUMMARY. The equipment at site Y consists of an HF single sideband radio and a 12-channel microwave system connecting the audio channels to the switchboard at site X. The radio equipment was found to be operating satisfactorily except for those deficiencies summarized in the following paragraphs.

2.2 RTEP 1, Transmitter RF Output Versus Frequency.

Sample RTEP report. (continued)

2.2.1 The HF transmitter output power as rated by the manufacturer is 1,000 watts, full duty cycle over the frequency range of 2-30 MHz. The equipment met this specification when tested into a dummy load on all frequencies except between 21-30 MHz. The maximum output that could be obtained over this frequency range was 920 watts. This may have been caused by the LC ratio of the dummy load rather than any problem associated with the transmitter.

2.2.2 The output power of the microwave transmitter according to the manufacturer's specifications is a nominal 0.750 watts when measured at the transmitter flange. Measured data indicated that the maximum obtainable output power was 0.386 watts. This indicates that the klystron should be replaced. Records are not maintained on klystron usage which could provide a valuable tool in determining when a klystron needs to be replaced.

2.3 RTEP 2, Transmitter Two-Tone Intermodulation Distortion. Within manufacturer's specifications.

2.4 RTEP 3, Transmitter Modulation Characteristics.

2.4.1 Transmitter modulation deviations on the microwave equipment were found to be 200 kHz and were adjusted to the manufacturer's specifications.

2.4.2 The composite audio input to the HF transmitter was found to be out of tolerance. This was adjusted to specifications and the transmitter input was checked for frequency response. During this phase of the test, there was considerable roll off at the high frequencies. This would indicate that the input circuitry components have changed in value.

2.5 Tests Within Specifications. The following tests were performed and the results were within specifications.

- RTEP 5, Transmitter Carrier Suppression.
- RTEP 6, Transmitter Carrier Frequency Accuracy.
- RTEP 7, Transmitter Spurious Emissions.
- RTEP 10, Radio FM Receiver Frequency Response.
- RTEP 11, Receiver FM Quieting, AGC, and Audio Output Characteristics.
- RTEP 13, Receiver Spurious Response.

2.6 RTEP 9, Antenna VSWR and Transmission Line Loss.

2.6.1 The HF transmitter used a three curtain Rhombic antenna and it was found that the VSWR over the frequencies of interest were out of specifications. The worst case was in the 12-16 MHz range where the VSWR measured 3.6:1. With this type antenna the VSWR should not exceed 2:1 over the usable range of the antenna.

Sample RTEP report. (continued)

2.6.2 The VSWR on the microwave system was measured using the return loss method. The system just barely met the 26 db return loss specification which appears to be caused by a small dent in the waveguide at the first coupling after it leaves the building.

3.0 OMITTED OR INCOMPLETE TESTS. The tests listed in table 1 were either not performed or performed in such a way as to invalidate the data.

TABLE 1

RTEP 12, Receiver Selectivity/IF Bandpass	Test equipment problem
RTEP 14, Receiver Sensitivity, AGC, Audio, and Squelch	Lack of TMDE
RTEP 16, Station Ground Measurement	Failed to perform

4.0 CONCLUSIONS. The radio systems are providing service to the customer; however, additional maintenance actions are required to improve the service.

5.0 TECHNICAL RECOMMENDATIONS.

5.1.1 Additional tests should be performed on the HF radio and dummy load to determine the maintenance required to improve the output power in the 21-30 MHz range (ref para 2.2.1).

5.1.2 The transmit klystron in the microwave system should be replaced. A record of klystron usage should also be established (ref para 2.1.2).

5.2 Onsite maintenance should periodically verify the transmitter deviation of the microwave system (ref para 2.4.1).

5.2.1 The input components of the HF system should be checked to determine the reason for high frequency roll off (ref para 2.4.2).

5.3 The Rhombic termination resistor may have changed value and require replacement. If this does not correct the problem, it may be necessary to perform VSWR measurements on the transmission line with a TDR to locate the fault.

5.4 The return loss on the microwave transmission lines should be checked periodically to verify that the system is not degrading below the 26 db standard.

6.0 DATA TABULATION. The entries in the data tabulation should be completed for each system evaluated. Enter NA for those areas not applicable and DNA when the data cannot be obtain or is not available.

Sample RTEP report. (continued)

APPENDIX C

RADIO NETWORKS TECHNICAL SCHEDULE AND ANTENNA CHARACTERISTICS

The following tables are provided as a handy reference to the technician. Antenna characteristics and selection criteria were extracted from MIL-STD-188-317, 30 March 1972.

TABLE C-1. TECHNICAL SCHEDULE FOR POST/CAMP RADIO NETWORKS

Performance Parameter	Units	Acceptance Limits									Applic. Proc.
		Base or Fixed Sta.	Vehicle	Ref.	Portable	Personal	Ref.	Air/Gd VHF	Air/Gd UHF	Ref.	
1. Transmitter Modulation, FM	kHz	±5	±5	F-1	±5	±5	F-6	–	–		3A
2. Transmitter Modulation, AM	%	–	–		–	–		95	95	G-1	3B
3. Transmitter Frequency Stability	%	±0.0005	±0.0005[1/] ±0.005[2/]	F-1	±0.0005[1/] ±0.005[2/]	±0.0005[1/] ±0.005[2/]	F-6 F-6	±0.005	±0.05	G-1	3C
4. Transmitter Audio Sensitivity	3/	3/	3/		3/	3/		–	–		3D
5. Transmitter RF Power Output	watts	3/	3/		3/	3/		–	–		3E
6. Receiver Sensitivity	uV, min	0.5	0.5	F-2	2.0[4/]	5.0[4/]	F-6	5	6	G-2	3F, 3G
7. Receiver Oscillator Frequency Stability	%	3/	3/		3/	3/		0.001	0.001	G-2	3H
8. Receiver Audio Power	watts, min	1.0[6/]	1.0[6/]	F-2	0.25[5,6/]	0.25[5,6/]	F-6	1.0[6/]	1.0[6/]	G-2	3I
9. VSWR											3J
a. Antenna End	ratio	1.5:1	1.5:1	F-7	–	–		2:1	2:1	G-3	
b. Transmitter End, Short Line (Attenuation >2 dB)	ratio	–	–		–	–		2.5:1	2.5:1	G-3	
c. Transmitter End, Long Line (Attenuation <2 dB)	ratio	–	–		–	–		2:1	2:1	G-3	

Note 1 – Final stage power input over 3 watts.

Note 2 – Final stage power input 3 watts or less.

Note 3 – Refer to specification value given in the manufacturer's manual for this equipment.

Note 4 – Open circuit (open circuit voltage is twice the voltage available across the receiver antenna input terminals if the receiver antenna input impedance is 50 ohms).

Note 5 – Loudspeaker output.

Note 6 – If the manufacturer's specified rating exceeds this value, the manufacturer's rating will take precedence.

C-2. ANTENNA CHARACTERISTICS.

Antenna Types Listed by Azimuthal Patterns and Polarization	Useful Frequency Range(MHz) (Note 1)	Power Gain (Referred to Istropic)(dB) (Note 2)	Usable Radiation Angles (degrees) (Note 3)	Land Required (acres)	Power Handling Capability (kW pep) (Note 4)
Unidirectional Patterns					
Horizontal Rhombic	2-30	8 to 23	4-35	5-15	Limited by Termination
Terminated V	2-30	6 to 13	5-30	4-9	
Horizontal Log-Periodic	2-30	10 to 17	5-45	2-10	40
Vertical Log-Periodic (Dipole)	2-30	6 to 10	3-25	3-5	40
Yagi (Horizontal)	6-30	12 to 19	5-30	< 1	20
Billboard (Horizontal)	4-30	9 to 17	5-30	1-2	40
Vertical Log-Periodic (Monopole)	2-30	4 to 8	3-25	3-5	20
Horizontal λ/2 Dipole	2-30	5 to 7	5-80	< 1	20
Omnidirectional Patterns (Vertical)					
Conical Monopole	2-30	-2 to +2	3-45	2-4	40
Discone	6-30	2 to 5	4-40	< 1	40
Inverted Discone	2-16	1 to 5	5-45	2-4	40
Sleeve (Not within the limits specified for antenna design, it is included due to its widespread use)	2-25	-1 to +3	4-40	2-4	10
Vertical Tower	2-30	-5 to +2	3-35	2-4	10

Note 1 - The useful frequency range is the range of the antenna type, not necessarily the bandwidth of an individual antenna.

Note 2 - Typical power gains are gains of antennas over good earth for vertical polarization and poor earth for horizontal polarization.

Note 3 - Usable radiation angles are typical radiation angles over good earth for vertical polarization and poor earth for horizontal polarization; lower angles may be possible for vertical antennas over better earth, e.g., sea water.

Note 4 - The power limitation criteria apply to the antenna only. The use of certain baluns may result in a lower power limitation. These criteria should be used as a basis of comparison only, since any antenna can be engineered, at increased cost, to provide increased power-handling capability.

C-2. (continued)

Approximate Material Cost (thousands) (Note 5)	Nominal Bandwidth Ratio (Note 6)	Nominal Bandwidth Limited by	Horizontal Beamwidth (-3 dB) (degrees)	Horizontal Beamwidth (-10 dB) (degrees)	Sidelobe Suppression (dB)	Transmit Maximum VSWR (Note 7)	Nominal Input Impedance (ohms)
5-10	≥2:1	Pattern	6°-26°	11°-46°	≥ 6	2:1	600
3-6	≥2:1	Pattern	8°-36°	11°-48°	≥ 6	2:1	600
15-25	≥8:1	VSWR	55°-75°	75°-120°	≥ 12	2:1	50/300
20-30	≥8:1	VSWR	90°-140°	150°-180°	≥ 12	2:1	50
5-10	≥3%	VSWR	28°-50°	38°-80°	≥ 9	1.5:1	50
10-15	NA	VSWR	50°-70°	80°-100°	≥ 12	2:1	50
20-30	≥8:1	VSWR	90°-140°	150°-180°	≥ 12	2:1	50
1-2	≥5%	VSWR	80°-180°/lobe	180°/lobe	NA	1.5:1	50
5-15	≥4:1	Pattern	NA	NA	NA	2.0:1	50
10-20	≥4:1	Pattern	NA	NA	NA	2.0:1	50
15-25	≥4:1	Pattern	NA	NA	NA	2.0:1	50
3-8	≥3:1	VSWR	NA	NA	NA	2.0:1	75
5-10	≥5%	VSWR	NA	NA	NA	1.5:1	50

Note 5 - Approximate material costs include steel towers, guys, and installation hardware. Costs are established only to provide a relative basis of comparison of one antenna against another.

Note 6 - Nominal bandwidth is the ratio of the two frequencies within which the stated vswr will not be exceeded or within which the desired pattern will not suffer more than 3 dB degradation.

Note 7 - Receiving antennas will have a maximum VSWR of 3.0:1.

C-3. ANTENNA SELECTION CRITERIA.

Path and Propagation Requirements (Gain, Radiation Angle, Azimuthal Coverage)	Performance Limits (Quantitative)	PRELIMINARY SELECTION — SUITABLE ANTENNA TYPES, IN ORDER OF PREFERENCE (Note 1)					
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Unidirectional Pattern							
High Gain, Low Angles	$G \geq 15$ dB $\Delta < 12^o$	Rhombic	Horizontal LP	Horizontal Yagi	Billboard		
Medium Gain, Medium Angles	$6dB<G<15$ dB $12^o<\Delta<24^o$	Rhombic	Vertical LP	Horizontal LP	Terminated V	Billboard	Yagi
Medium Gain, Low Angles	$6dB<G<15$ dB $\Delta \leq 12^o$	Rhombic	Vertical LP	Yagi	Horizontal LP	Terminated V	Billboard
Medium Gain, High Angles	$6dB<G<15$ dB $\Delta \geq 24^o$	Horizontal LP	Rhombic	Yagi	Terminated V	Horizontal Half-Wave Dipole	
Omnidirectional Pattern							
Low Gain, Low Angles	$G \leq 6$ dB $\Delta \leq 12^o$	Conical Monopole	Discone	Inverted Discone	Sleeve	Vertical Tower	
Low Gain, High Angles	$G \leq 6$ dB $\Delta > 24^o$	Conical Monopole	Discone	Inverted Discone	Vertical $\lambda/4$		

Note 1 - The order of preference indicated is based on the relative simplicity of a particular antenna to meet a given requirement.

Note 2 - The space limitation of 4 acres is based on the approximate land area required for a good ground system for vertical antennas, and includes requirements for guying. The antenna system is taken to mean all the antennas required to support the transmit side of a circuit (e.g., 2 or 3 antennas may be required to provide full frequency coverage). Normally more than twice the amount of land is required for space diversity reception.

C-3. (continued)

LIMITING CHARACTERISTICS									
SPACE LIMITATION		COST LIMITATION			FREQUENCY LIMITATION	POWER LIMITATION			
If Less Than 4 Acres of Space Per Antenna System is Available, Eliminate: (Note 2)		If Less Than $10,000 Per Antenna is Available for Material, Eliminate: (Note 3)			If Operated Below 6 MHz, Eliminate: (Note 4)	If Power Level Exceeds 40 kW PEP Eliminate: (Note 5)			
Rhombic		Horizontal LP	Billboard		Yagi	Horizontal LP	Yagi	Billboard	
Rhombic Terminated V	Vertical LP	Horizontal LP	Vertical LP	Billboard	Yagi	Horizontal LP	Vertical LP	Billboard	Yagi
Rhombic Terminated V	Vertical LP	Vertical LP	Horizontal LP	Billboard	Yagi	Vertical LP	Horizontal LP	Billboard	
Rhombic	Terminated V	Horizontal LP			Yagi	Horizontal LP	Yagi	Horizontal Half-Wave Dipole	
		Discone	Inverted Discone	Vertical Tower	Discone	Discone & Inverted Discone	Vertical Tower	Sleeve	
		Discone	Inverted Discone	Vertical λ/4	Discone	Discone	Inverted Discone	Vertical λ/4	

Note 3 - Costs are computed on the basis of the combined costs of the antenna kit, steel towers, guys, and installation hardware; the breakoff point of $10,000 is established only to provide a relative basis of comparison of one antenna type against another.

Note 4 - It is recommended that the horizontal Yagi not be considered for use below 6 MHz. In addition, for operation below 10 MHz the inverted discone should be considered in lieu of the discone.

Note 5 - The power limitation criteria apply to the antenna only. The use of certain baluns may result in a lower power limitation. These criteria should be used as a basis of comparison only, since any antenna can be engineered, at increased cost, to provide increased power-handling capability.

FOR THE COMMANDER:

OFFICIAL

A.A. Remling, II

A.A. REMLING, II
Major, AGC
Adjutant General

C.E. MCKNIGHT, JR.
Colonel(P), GS
Chief of Staff

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PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

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